INSTRUMENTS AND AUTOMATION

JANUARY
1958

30th ANNIVERSARY ISSUE

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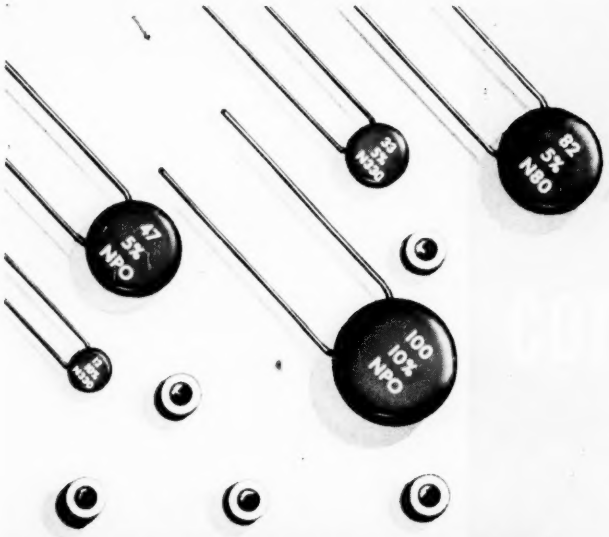

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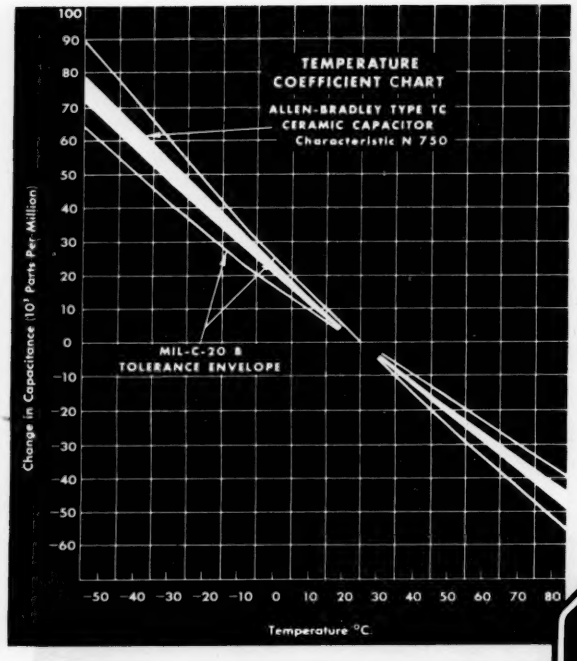

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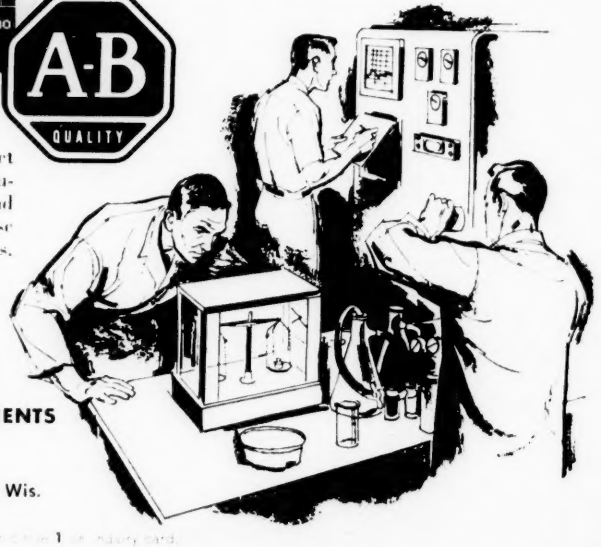

In modern laboratories, Allen-Bradley physicists conduct exacting tests on ceramic disc capacitors. The data accumulated from many thousands of tests—both electrical and physical—enables Allen-Bradley to produce ceramic disc bodies with *exact* temperature compensating characteristics.

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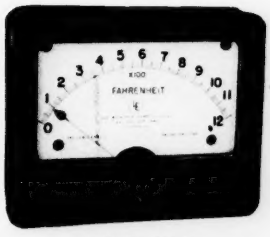
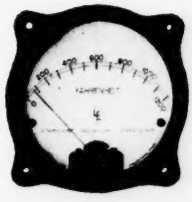


MODEL 58PY

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many marine diesel installations for measuring exhaust temperatures. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple materials.



MODEL 23B

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2⅛ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

MODEL 20B

The Model 62RT4F resistance thermometer is a sturdy easy-to-read instrument with a 6 in. hand drawn scale. It is suitable for use in moving vehicles and is excellent for flight-test work. It is operated by an ordinary dry cell and is calibrated to standard "AN" bulb curves for various ranges in fahrenheit or centigrade.

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THERMOCOUPLES for use with the above indicators are available in many styles for special applications. We have developed a complete line of aircraft, industrial and automotive thermocouples and would be pleased to offer our recommendation for your application.

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RESISTANCE BULBS for use as sensing elements for the 62RT4 thermometers are available in several types for various applications, for measuring free air or liquid temperatures. We invite inquiries on your application.

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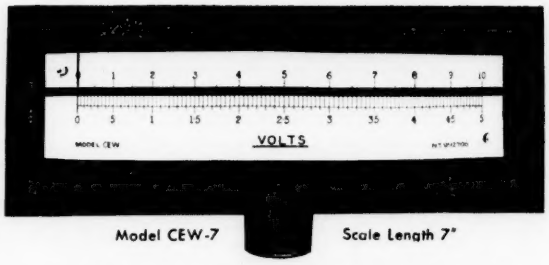

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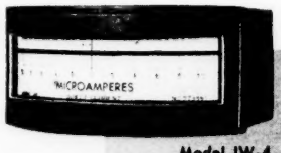

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THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL SINCE JANUARY 1928

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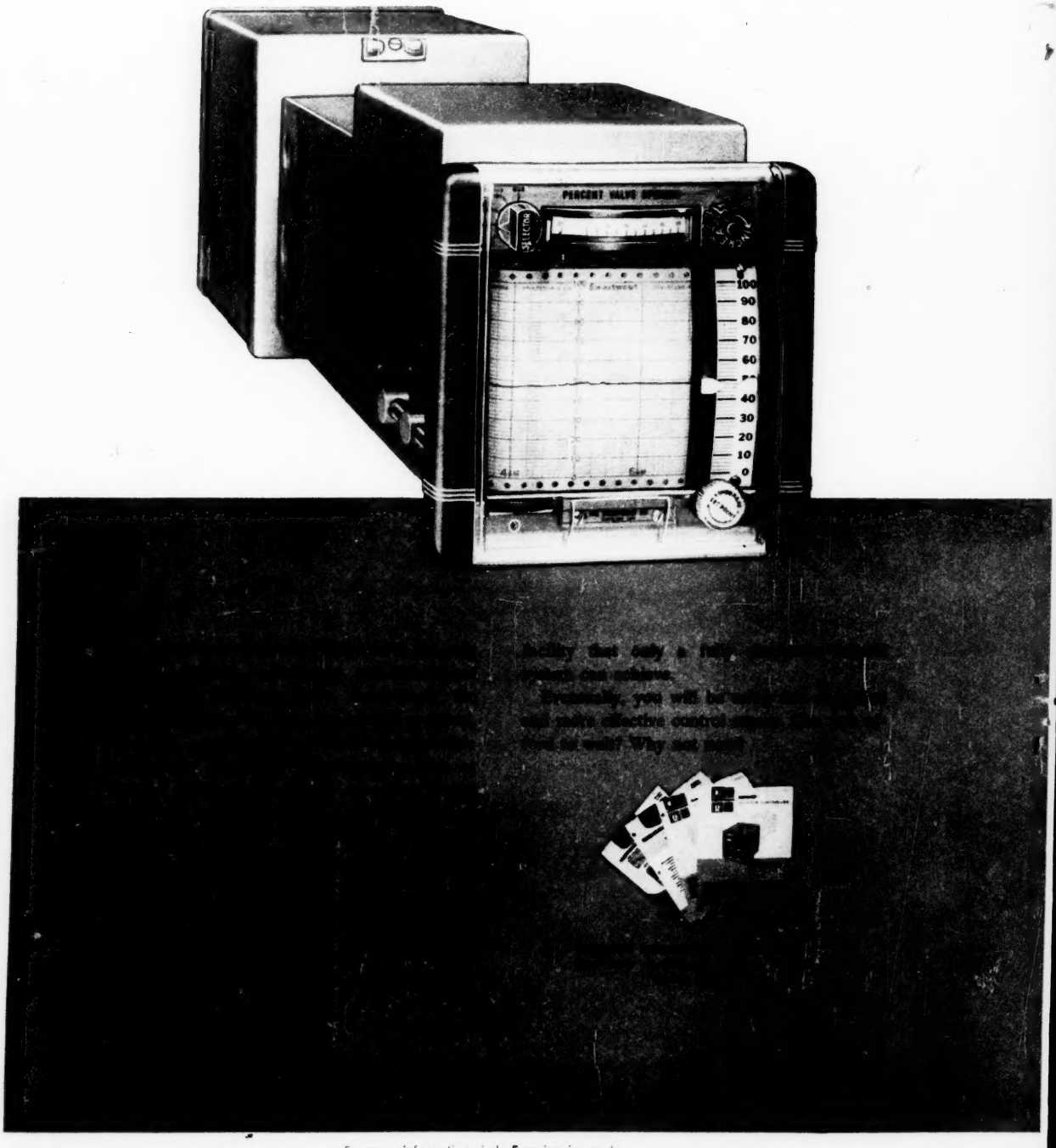

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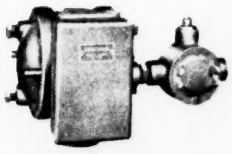
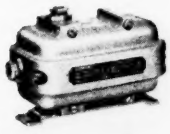
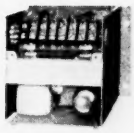


Barton Flow Meter



Power Relay



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Absolute Pressure

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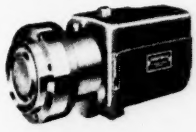


Differential Pressure

Ratio Adapter

Resistance Thermometer

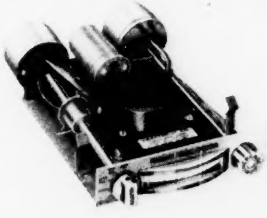
Thermocouple Converter

Level

Motor Control Adapter

Flush Diaphragm Pressure

are locked out. All of this equipment is



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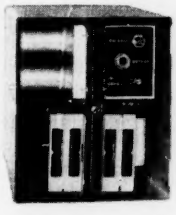

No controller has ever been as completely . . . or as sensibly . . . unitized. Plug-in printed circuity permits inter-changing of electronic circuits for maintenance or for changes in control function.

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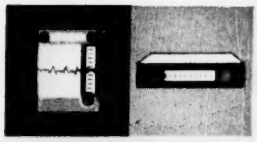

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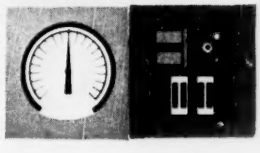

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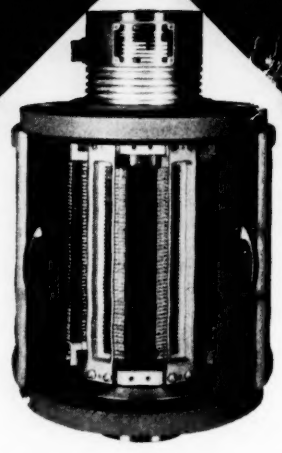

The new 512A Bryant general purpose magnetic storage drum is built to meet the exacting requirements of all permanent storage problems, yet is versatile enough to be used as a laboratory instrument. It is the result of 25 years' experience in designing and producing high-speed precision spindles. These standard 5" dia. x 12" long drums are stocked for immediate shipment at a price that reflects quantity manufacture, far below the cost of customer-designed drums.

Features:

- Guaranteed accuracy of drum run-out, .00010" T. I. R. or less.
- Integral motor drive – Bryant precision motor
- Capacities to 625,000 bits
- Speeds up to 12,000 R. P. M.
- 500 kilocycle drum operation possible
- Accommodates up to 240 magnetic read/record heads
- Provides for re-circulating registers as well as general storage
- High density ground magnetic oxide coating
- Super-precision ball bearing suspension
- Vertical mounting for trouble-free operation

Write for complete details on the new No. 512A

BRYANT GAGE and SPINDLE DIVISION
P. O. Box 620-I, Springfield, Vermont, U. S. A.
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to the editor

Editor, I&A:

After reading the editorial "Pittsburgh's Answer to Sputnik," I flew to Pittsburgh to observe this education experiment.

I observed a singularity of purpose in seeing to it that because it was an experiment, it should be so carried out that the student preeminently got at the "why" of the material. The concept of the scientific method is perhaps one of the most difficult of all to teach secondary school youth, but I saw in your teachers the reserved judgement approach, and on the bench the material wherewith to have their students gather data. The course cannot be considered vocational, but it is "vocational" in the best sense, where a level of thinking consonant with college preparation, i. e., deeper and broader understanding of principle, is the vocation. The students are indeed privileged to rub elbows with a working functional living part of the very economy of which they too will shortly be an operative part.

The design of the project reveals a process upon which I would like to comment. This class reflects the public. To help make educational policy which reflects if indeed does not directly mold public policy, the schoolman must know his community, his nation, the world situation. Pittsburgh schoolmen and Pittsburgh technical citizenry have cooperated uniquely in developing this joint project. Observe the range of the implications. I admire you people for having the insight to set up such an experiment and to staff it with the calibre of person you selected. I think you have something which deserves our attention, "our" being the nation's public, and "our" at the same time being this particular writer. I might say that I have been studying administration now for some seven years at Columbia. What you showed me in Pittsburgh classes with best practice, not just best principle.

Bartlett E. S. Chappell,
Dean, New York Military Academy,
Cornwall-On-Hudson, N. Y.

Editor, I&A:

I have read with considerable interest your editorial "Pittsburgh's

Answer to Sputnik." You might also be interested in knowing that it was also read at a meeting of local school directors held in Harrisburg.

The course which has been established warrants all the national publicity which you can give it through your magazine. Certainly, something must be done to present a picture of the true situation to industry and to the public at large. To me, the greatest need right now is for properly trained people who can support our trained engineers and scientists rather than going into a crash program for the development of scientists alone.

Those of us in Trade and Industrial Education have realized this for some time. Our biggest difficulty as far as high school is concerned is to get administrators of local educational programs to realize that science, either chemistry, physics, or mathematics, taught as it is today in high schools is not going to attract any additional number of interested students. There must be some motivation in terms of practical application, such as you are doing in this course and such as we have always recommended, before young people are going to show any increased interest in science and mathematics.

If it is at all possible, I would like to have twenty to twenty-five copies of your article in order to spread through the department and also forward to other people who I know are interested in this particular type of educational program.

William L. Cooper, Chief
Trade and Industrial Education
Commonwealth of Pennsylvania
Department of Public Instruction
Harrisburg, Penna.

Editor, I&A:

The editorial "Pittsburgh's Answer to Sputnik" which appeared in the November issue of *Instruments and Automation* should do much to stimulate thinking on expanded scientific educational training in other large city schools. In view of recent developments I believe that Pittsburgh's indoctrination of high-school students to science and technology should receive wider national newspaper coverage.

The effectiveness of this first program in Pittsburgh schools is far less important than the fact that you have taken the effort to establish a program, any program. The Committee of Consultants to the Pittsburgh Board of Education on Instruments/Automation Education deserves much

RAMBLINGS ON INSTRUMENTATION

The Hays Menu of Combustion Guides

Wherever fuel is burned in any quantities, it makes good economic sense to invest in an instrument to continuously indicate and/or record combustion efficiency—that is, a combustion guide. Hays offers the most complete line of such instruments including:

1. The Magno-Therm Oxygen Analyzer
2. The Boiler Efficiency Meter or Air-Flow/Steam-Flow Meter
3. The Combustion Meter or Automatic Orsat
4. The Condu-Therm CO_2 Analyzer, an all electronic thermal conductivity measuring instrument

This month we'd like to describe the merits of:

Item 1—Oxygen on the Half Cell or La Pièce de Paramagnetic

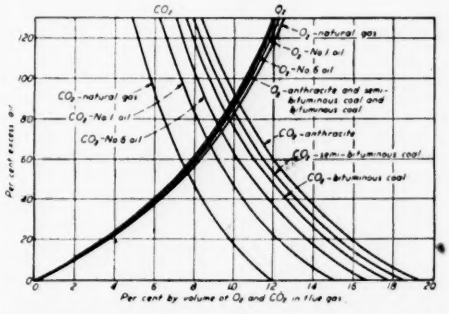
This fine product has been affectionately nicknamed the Hays Magno-Therm Oxygen Analyzer. It is, to put it flatly, the most widely accepted industrial type oxygen analyzer currently in production in the U.S.

Its operation is based on the exceptional paramagnetic property of oxygen, a quality not found in other commonly used industrial gases. No sample preparation is required other than nominal filtering and cooling. Its analyzing cell is inert, needs no electrode replacements and requires no fuel supply.

Ranges vary from a minimum of 0-5% to a maximum of 0-100%, with suppressed zero ranges of a minimum 5% anywhere in the spectrum. For example: 17 to 22% for analyzing the oxygen in smoke-filled rooms.

Some of the advantages of the Hays analyzer include high degree of sensitivity, rapid response, and almost monotonous accuracy.

O_2 analysis is particularly handy when switching from one fuel to another or burning more than one fuel at the same time. Why? Because oxygen and oxygen alone gives you an undistorted picture of the amount of excess air present in combustion gases. This fact is borne out by the graph below showing the relationship of excess air to CO_2 and O_2 in the flue gas of five common fuels. While the O_2 curves nearly coincide (especially in the important 30% excess air range) the CO_2 curves diverge widely. With any other type of combustion guide, you would have to re-calibrate for each fuel (when switching from one to another) or put up with extremely unreliable information (when burning multiple fuels).



Note uniformity of O_2 compared to CO_2, burning fuels of varying hydrogen/carbon ratios. (Write for detailed chart, 8½x11" in one glorious color, suitable for framing.)

We have a rather fascinating tome entitled "Combustion and Combustion Guides" which goes into this sort of thing in elaborate detail. If you'd like a copy, address your request to my personal attention and I will send you one promptly.

Phil Sprague Jr.

President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

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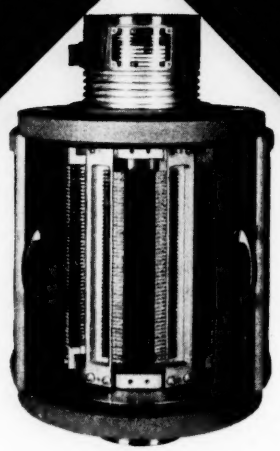
BRYANT MAGNETIC STORAGE DRUM

Economical . . . Precise . . . and Versatile!



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- Super-precision ball bearing suspension
- Vertical mounting for trouble-free operation

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P. O. Box 620-I, Springfield, Vermont, U. S. A.
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Editor, I&A:

After reading the editorial "Pittsburgh's Answer to Sputnik," I flew to Pittsburgh to observe this education experiment.

I observed a singularity of purpose in seeing to it that because it was an experiment, it should be so carried out that the student preeminently got at the "why" of the material. The concept of the scientific method is perhaps one of the most difficult of all to teach secondary school youth, but I saw in your teachers the reserved judgement approach, and on the bench the material wherewith to have their students gather data. The course cannot be considered vocational, but it is "vocational" in the best sense, where a level of thinking consonant with college preparation, i. e., deeper and broader understanding of principle, is the vocation. The students are indeed privileged to rub elbows with a working functional living part of the very economy of which they too will shortly be an operative part.

The design of the project reveals a process upon which I would like to comment. This class reflects the public. To help make educational policy which reflects if indeed does not directly mold public policy, the schoolman must know his community, his nation, the world situation. Pittsburgh schoolmen and Pittsburgh technical citizenry have cooperated uniquely in developing this joint project. Observe the range of the implications. I admire you people for having the insight to set up such an experiment and to staff it with the calibre of person you selected. I think you have something which deserves our attention, "our" being the nation's public, and "our" at the same time being this particular writer. I might say that I have been studying administration now for some seven years at Columbia. What you showed me in Pittsburgh classes with best practice, not just best principle.

Bartlett E. S. Chappell,
Dean, New York Military Academy,
Cornwall-On-Hudson, N. Y.

Editor, I&A:

I have read with considerable interest your editorial "Pittsburgh's

Answer to Sputnik." You might also be interested in knowing that it was also read at a meeting of local school directors held in Harrisburg.

The course which has been established warrants all the national publicity which you can give it through your magazine. Certainly, something must be done to present a picture of the true situation to industry and to the public at large. To me, the greatest need right now is for properly trained people who can support our trained engineers and scientists rather than going into a crash program for the development of scientists alone.

Those of us in Trade and Industrial Education have realized this for some time. Our biggest difficulty as far as high school is concerned is to get administrators of local educational programs to realize that science, either chemistry, physics, or mathematics, taught as it is today in high schools is not going to attract any additional number of interested students. There must be some motivation in terms of practical application, such as you are doing in this course and such as we have always recommended, before young people are going to show any increased interest in science and mathematics.

If it is at all possible, I would like to have twenty to twenty-five copies of your article in order to spread through the department and also forward to other people who I know are interested in this particular type of educational program.

William L. Cooper, Chief
Trade and Industrial Education
Commonwealth of Pennsylvania
Department of Public Instruction
Harrisburg, Penna.

Editor, I&A:

The editorial "Pittsburgh's Answer to Sputnik" which appeared in the November issue of *Instruments and Automation* should do much to stimulate thinking on expanded scientific educational training in other large city schools. In view of recent developments I believe that Pittsburgh's indoctrination of high-school students to science and technology should receive wider national newspaper coverage.

The effectiveness of this first program in Pittsburgh schools is far less important than the fact that you have taken the effort to establish a program, any program. The Committee of Consultants to the Pittsburgh Board of Education on Instruments/Automation Education deserves much

RAMBLINGS ON INSTRUMENTATION

The Hays Menu of Combustion Guides

Wherever fuel is burned in any quantities, it makes good economic sense to invest in an instrument to continuously indicate and/or record combustion efficiency—that is, a combustion guide. Hays offers the most complete line of such instruments including:

1. The Magno-Therm Oxygen Analyzer
2. The Boiler Efficiency Meter or Air-Flow/Steam-Flow Meter
3. The Combustion Meter or Automatic Orsat
4. The Condu-Therm CO_2 Analyzer, an all electronic thermal conductivity measuring instrument

This month we'd like to describe the merits of:

Item 1—Oxygen on the Half Cell or La Pièce de Paramagnetic

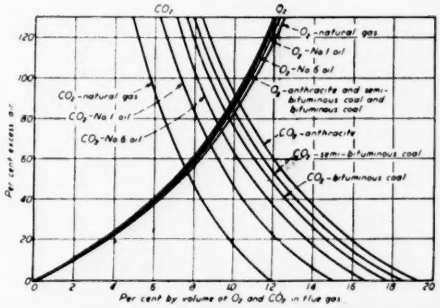
This fine product has been affectionately nicknamed the Hays Magno-Therm Oxygen Analyzer. It is, to put it flatly, the most widely accepted industrial type oxygen analyzer currently in production in the U.S.

Its operation is based on the exceptional paramagnetic property of oxygen, a quality not found in other commonly used industrial gases. No sample preparation is required other than nominal filtering and cooling. Its analyzing cell is inert, needs no electrode replacements and requires no fuel supply.

Ranges vary from a minimum of 0-5% to a maximum of 0-100%, with suppressed zero ranges of a minimum 5% anywhere in the spectrum. For example: 17 to 22% for analyzing the oxygen in smoke-filled rooms.

Some of the advantages of the Hays analyzer include high degree of sensitivity, rapid response, and almost monotonous accuracy.

O_2 analysis is particularly handy when switching from one fuel to another or burning more than one fuel at the same time. Why? Because oxygen and oxygen alone gives you an undistorted picture of the amount of excess air present in combustion gases. This fact is borne out by the graph below showing the relationship of excess air to CO_2 and O_2 in the flue gas of five common fuels. While the O_2 curves nearly coincide (especially in the important 30% excess air range) the CO_2 curves diverge widely. With any other type of combustion guide, you would have to re-calibrate for each fuel (when switching from one to another) or put up with extremely unreliable information (when burning multiple fuels).



Note uniformity of O_2 compared to CO_2, burning fuels of varying hydrogen/carbon ratios. (Write for detailed chart, 8½x11" in one glorious color, suitable for framing.)

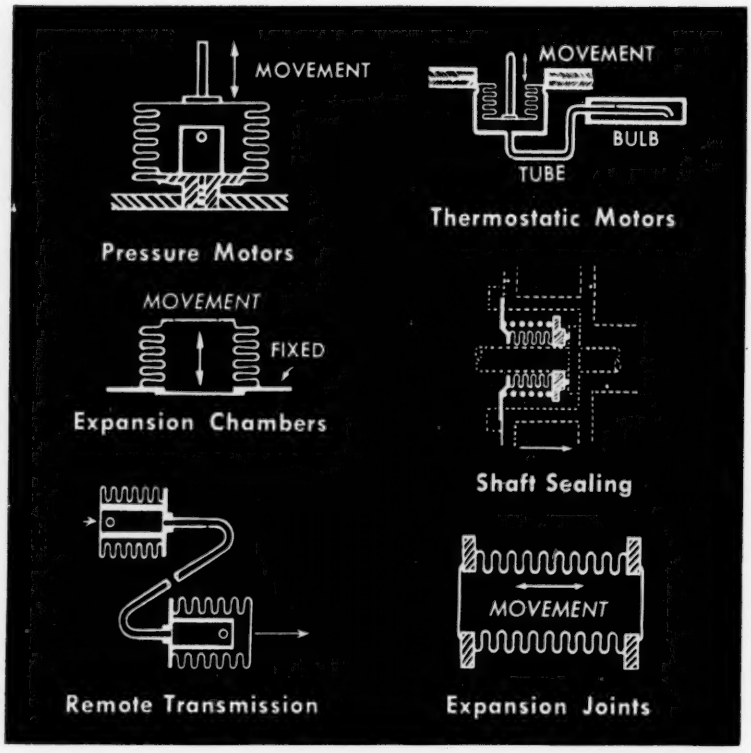
We have a rather fascinating tome entitled "Combustion and Combustion Guides" which goes into this sort of thing in elaborate detail. If you'd like a copy, address your request to my personal attention and I will send you one promptly.

Phil Sprague Jr.

President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

For more information circle 7 on inquiry card.



ELIMINATE DESIGN "WEAK SPOTS" WITH Bridgeport SEAMLESS BELLOWS

The simple construction, straightforward operation, and light weight of Bridgeport seamless metal bellows make them the best answer for many temperature, pressure, and mechanical design problems. Hydraulically formed without soldered seams, they provide added strength and precision in shaft sealing, in obtaining controlled movement, in absorbing expansion or shock, in maintaining equal or differential pressures, and in transmitting motion remotely.

Bridgeport also offers two plus factors to make the most of any bellows application. Through integrated engineering of the bellows and all accessories, Bridgeport can supply complete bellows assemblies of many types, sizes, and metals. Ultra-modern production and quality control facilities assure increased uniformity and cost savings.

SEND FOR BELLOWS BULLETIN-F-101

Mr. Controls®
Robertshaw-Fulton
CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION
MILFORD • CONNECTICUT

For more information circle 8 on inquiry card.

LETTERS —CONTINUED

credit for its fortitude in carrying out this program.

D. E. Kunkle
Physical Metallurgy Div.
Aluminum Co. of America
New Kensington, Pa.

Editor, I&A:

I read with interest and disappointment your editorial "Pittsburgh's Answer to Sputnik."

My disappointment was caused in that the article had in mind only the ten percent of high school students who will enter college. How few of these will be interested in chemistry, electronics, engineering and science? What about the other ninety percent of high school graduates? Where will our lab technicians and engineering aides come from?

Your philosophy on education seems to be the same as the academic teachers. The trade or vocational school's part in educating the other ninety percent is discounted or forgotten altogether.

Joseph W. Turner
Director
Jefferson Trade School
Gretna, La.

The course combines "vocational" and "academic" subjects in a new and powerful manner. Nothing prevents the concept from spreading to trade schools—and we hope to do that in the near future!

Editor, I&A:

Kindly send me prepaid the following: 100 *Electronic Circuits* by M. H. Aronson & C. F. Kezer.

I also wish to mention that I received my other order, *Electronic Circuitry for Instruments and Equipment* and find this the finest book I have had the pleasure to study. I have read many books on this subject but this one tops them all!.

I find your magazines very helpful.

John J. Oskay
E. R. Squibb & Sons
New Brunswick, N. J.

The second edition of this book is now available at $2.00. (first edition sold out at $4.00.)

Reader Inquiries

Small Gear Trains

Instrument maker is seeking information on small gear trains, how to hold backlash gears while assembling them, making small reamers, staking punches, etc. A-286

Radiation Counter

Reader is seeking sources of supply for "radiation meters which will find where the dangerous spots are brought about by fall-out." A-287

Magnetic-field and Flux Intensity

Lecturer in Electrical Engineering at university would like to get information and literature on precise measurement of magnetic field intensity and magnetic flux density in open and closed magnetic circuits. A-288

Plastic Bellows

Engineer with milk processing company is seeking plastic bellows for removal of air from cylinder. Must withstand 28" vacuum against outside atmospheric pressure. A-289

Locator for Ferrous Material

Italian company is seeking instrument "suitable to effectuate subacqueous sounding to note the presence of ferrous materials in a river bed." A-290

Gas-mixture Control

Research engineer of large electronics manufacturer is seeking equipment to test and control percentage of helium vs nitrogen (approximately 5% He and 95% N) in hermetically sealed electronic packages containing approximately 30 to 40 cu in. A-291

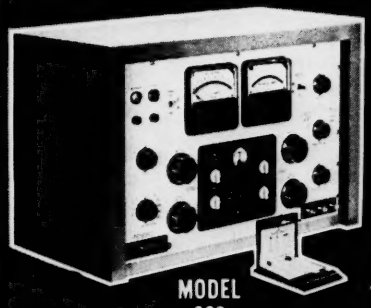
Small Chain-and-Sprocket Drives

Teacher at radio engineering school seeks sources of supply for small pulley-and-belt, and chain-and-sprocket drives for servomechanisms. A-292

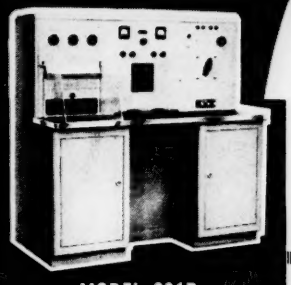
Continuous Powder pH Reading

Chocolate manufacturer seeks indicator for continuous reading of pH in powder containing 14 to 18% moisture at 190 to 200° F without resorting to slurry. Accuracy required: 0.05 pH with overall tolerance of 0.1. Expected reading 8 to 10 pH. A-293

Instrument Calibration



a modern method of maintaining ACCURACY



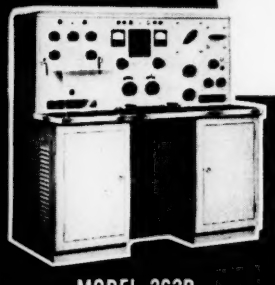
Superior and sustained quality control, through frequent calibration of test instruments, can be achieved by semi-skilled personnel using these self-contained standards.

Portable Model 829 calibrates both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes. Direct reading accuracy of 1% (0.5% using charts supplied). Output frequency from 50 to 400 cps depending on line frequency used.

Net price $2,650.

Console Model 261B calibrates all types of AC meters to direct reading accuracies of 0.5% (0.25% using calibration charts) over frequency range of 50 to 1600 cps. Current range from 1.5 milliamperes to 200 amperes; voltage range from 75 millivolts to 1500 volts. Output of electronic power oscillator has less than 5% total harmonic content at 60 cycles.

Net price $9,250.



Model 262B Dual Potentiometer Standard calibrates DC electrical measuring instruments to direct reading accuracies of 0.1% (0.05% using calibration charts) through voltages ranging from 1 millivolt to 1500 volts and currents ranging from 1 microampere to 150 amperes. Employs Weston instruments and standard cells.

Net price $15,600.

Prices are f.o.b. Boonton, N.J. & subject to change without notice.

WE CAN HELP YOU

Technical and application data for our six basic models are fully described in a new 24-page catalog. Send for it today.

RFL Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U.S.A.

For more information circle 9 on inquiry card.

news

4th Int'l Automation Show To Feature 160 Clinics

PITTSBURGH, PA.—Preliminary arrangements for the Fourth International Automation Exposition, to be held in the New York Coliseum June 9-13, 1958 include (1) 160 separate clinic sessions on exhibited equipments, (2) a 2-day conference on *Human Factors in Systems Engineering* directed by Dr. Douglas Courtney of Courtney & Co., Phila., (3) a 2-day Conference on *Automatic Data Processing For Senior Executives*, directed by Gordon L. Mattson, Chicago consultant, (4) 2-day conference on *Plant layout for Automation*, directed by H. H. Dasey, President of Visual Plant Layouts, and (5) nine technical sessions. The sessions and session chairmen are as follows: *Data Acquisition and Reduction*—Ward O'Connor, Chief Mechanical Engineer, Lummus Company; *Automatic Control Valves*—E. Albert Adler, Instrument Engineer, United Engineers & Constructors, Inc.; *Medical Instrumentation and Electronics*—Dr. Raymond Jonnard, Prudential Life Insurance Co.; *Military Electronics and Controls*—Commander Claude Morrison, Editor, *Military Automation* magazine; *Education for Automation & Instrumentation*—Milton Aronson, Editorial Director, *Instruments Publishing Co.*; *Importance of Measurements*—Douglas Considine, Products Div., Hughes Aircraft.

Chairmen of sessions on *Machine Automation*, *Automatic Weighing*, and *Product Design for Automation* will be announced soon.

Richard K. West

Richard K. West, president of West Instrument Corp., Chicago, became the victim in December of a tragic airplane accident. His private plane, which he piloted, was lost in Lake Erie. He was also chairman of West Instrument Ltd. of England, a Commander in the U. S. Navy, and head of all Naval Reserve activities at Glenview, Ill., Naval Air Base.

Leland K. Spink

Leland K. Spink, engineer in charge of flow measurement at the Foxboro Company died at the age of 58, December 23, 1957 in Foxboro, Mass. An outstanding authority on flow he was author of the books *Principles and Practice of Flow Meter Engineering* and *Handbook of Stream Flow Measurement*. He won wide recognition as a pioneer in calculating and coordinating flowmeter engineering.

Basil M. Goldsmith

Basil M. Goldsmith, 49, material control manager of Industrial Tube Div., Allen B. Du Mont Laboratories, Inc., died suddenly on December 6. Mr. Goldsmith, television and electronics pioneer, helped build the first Du Mont electronic television receiver in 1938.

Nuclear Package For Colleges Costs $30,000

CHICAGO, ILL.—A small 6' high by 4' diameter water-moderated, natural-uranium-fueled subcritical reactor, plus complete instrumentation, is now available to colleges. The package, complete with a manual of 30 experiments costs less than $30,000 (without fuel). It is offered by Nucear-Chicago Corporation, Chicago 10, Ill.

Refinery Uses Electrohydraulic Control

PORT CREDIT, ONTARIO—Regent Refining (Canada) Limited is on-stream with a UOP fluid catalytic cracking unit of 7000 B/SD fresh charge, a UOP polymerization unit, and gas-concentration facilities. These are said to be "first refining units in the world designed to operate without employing air in any phase of instrument work." Electric and electronic control instruments are used with electrohydraulic valves.

The Twistor

NEW YORK, N. Y.—A new concept in memory devices has emerged from exploratory work by A. H. Bobeck at Bell Telephone Laboratories. This new concept gets its name, "Twistor," from a characteristic of

Circle 10 on inquiry card ⟶

This AC Regulator?

Get In Line!

Sorensen AC Line Regulators Handle 150 VA to 15 KVA; Accurate within ±0.1% against Line or Load. Highly Dependable with Clean Wave Form and Frequency Insensitivity.

It's a sure thing you can depend on a sustained steady voltage level, in circuit or hook-up, when there's a Sorensen AC Line Voltage Regulator cut into your power source.

On applications such as communications equipment, appliance testing, instrument calibration, and color photography—and for general laboratory use, the refined Sorensen regulating circuit gives unequaled accuracy and dependability.

An exclusive factor, unique and effective, is the safety diode which produces a voltage drop, in place of a surge, when there's a filament break in any tube. Over-voltage circuit breakers are also included in units of more than one KVA rating.

The unusual reliability and acceptance of these voltage regulators is established overwhelmingly by the thousands of installations using them throughout the world, with great numbers of these Sorensen units in continuous service for ten years and more.

Check your local Sorensen representative on what these line voltage regulators can do in your operations. Or, for technical data, write directly to **SORENSEN & COMPANY, Inc.,** *Richards Avenue, South Norwalk, Conn.*

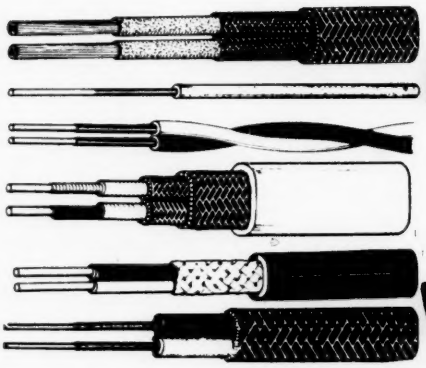
SPECIFICATIONS Model 1000 S* (illustrated)

Output voltage	115 VAC, single phase, adjustable 110-120 volts	**Power factor range**	From unity to 0.7% lagging
Input Voltage	95-130 VAC, single phase, 50/60 cycles, ±10%	**Load range**	0 to full
Regulation accuracy	±0.1%, against line; ±0.1%, against load	**Width**	17¼"
Distortion produced	3% Max.	**Height**	8¼"
Time constant	0.1 second	**Depth**	11"
		Rack mount height	8¼"
		Net weight	75 lbs.
		Shipping weight	87 lbs.

*Ask for data on other models and capacities.

Sorensen

controlled power for research and industry



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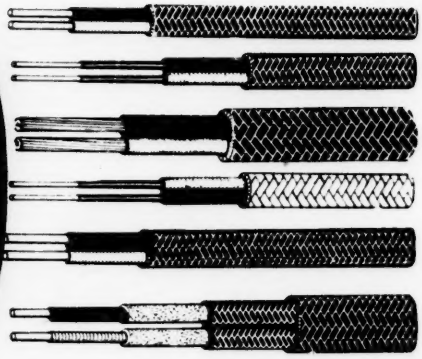


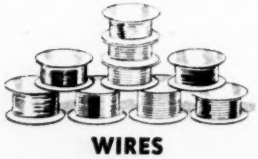
Frank Hack

Richard Rimbach

Avery Hack

By a pleasant coincidence we, like the Instruments Publishing Company, are also commencing our thirtieth milestone in business. So, at the helm of the New Year, we lift a toast to publisher Richard Rimbach and his staff who have so well served the men of pyrometry these past thirty years. Industrial Pyrometer & Supply Co. has since its inception strived to do one thing well . . . produce the highest quality insulated thermocouple lead wires and pyrometer accessories at the lowest possible cost and give prompt delivery service. So during the year ahead look to industrial for your thermocouple lead wire and pyrometer accessory needs. Request a copy of our latest catalog #14 illustrating and describing our complete line of insulated thermocouple lead wires and pyrometer accessories. Let us convince you that for highest quality, lowest prices and prompt delivery service Industrial can serve you best.

Ask For Our New Catalog #14



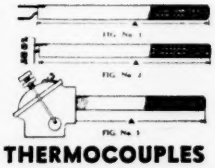
WIRES

THERMOCOUPLE LEAD WIRES

INSULATORS

THERMOCOUPLE HEADS

TUBES



THERMOCOUPLES

Industrial Pyrometer and Supply Co. ALTON ILLINOIS, U.S.A.

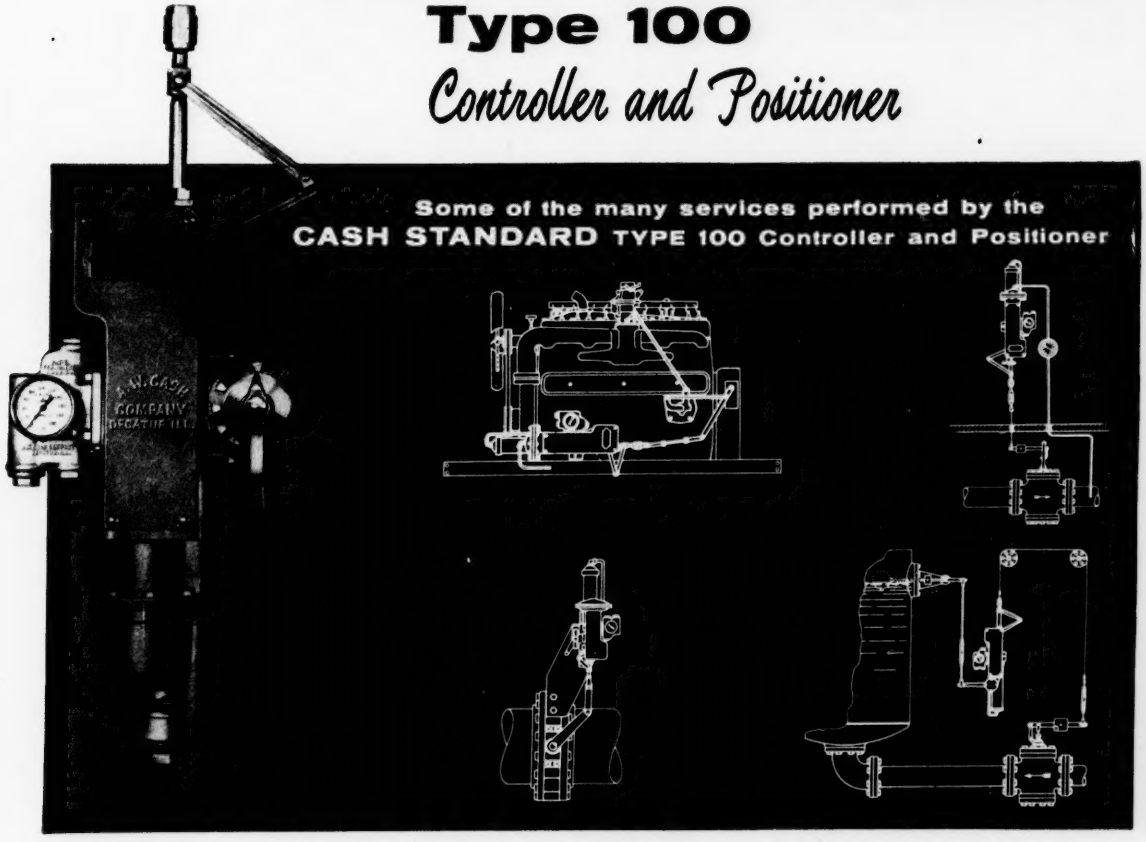
Worlds largest manufacturer of Pyrometer and Thermocouple Extension Lead Wire
WE OPERATE OUR OWN WIRE INSULATING MILLS • LARGE SUPPLY CONTRACTS OUR SPECIALTY

For more information circle **11** on inquiry card.

automatic control or positioning problem?

Here's the answer . . . the versatile

CASH STANDARD
Type 100
Controller and Positioner



Include this unit in your process system as:

1. A controller with self-contained positioning mechanism.
2. A power positioner actuated by a signal from another controller.

The Type 100 coupled with various types of final control elements will accurately control:
• Pressure • Liquid level • Rate of flow • Other process variables

The Type 100 features: • Feed back type control • Adjustable range • High sensitivity • Linear or curved line characteristics • Reverse or direct action • Optional manual control • Double acting cylinders, 6″ or 12″ stroke, 2″, 2¾″ or 4″ bore for operating pressures up to 125 psi. (Also suitable for larger cylinders in combination with volume booster when higher thrusts are desired.) • Operation by air, oil or clean water.

Available for these signal ranges: • Vacuum • Differential pressure • Pressures up to 600 psig. • Lever motion

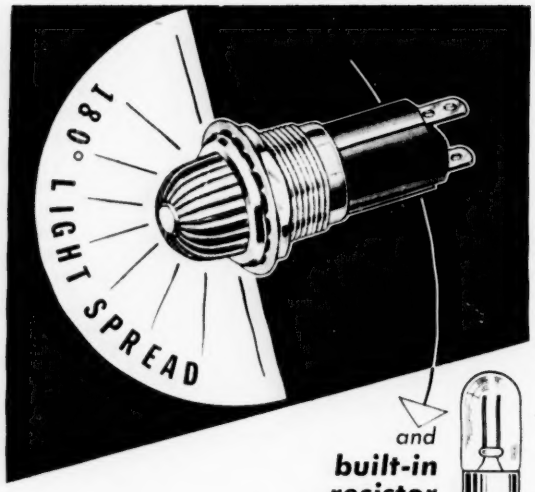
WRITE TODAY for complete information, including literature, on this versatile instrument. DEPT. O

CASH STANDARD

A. W. CASH COMPANY, P. O. Box 551, Decatur, Illinois

Pressure, Hydraulic, Temperature, Process and Combustion Controls

For more information circle **12** on inquiry card.



and
built-in resistor
for Neon lamp
. . . a patented DIALCO feature

NE-51

. . . two of many special features obtainable in

DIALCO PILOT LIGHTS

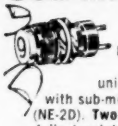
The DIALCO series of Pilot Lights, exemplified by the unit shown above, is designed to house the *NE-51 Neon Glow Lamp*, and for *direct use on 125 volt to 250 volt circuits*. Since Neon lamps require a current limiting (ballast) resistor, the necessary resistor is ***"built-in"***— an integral part of the lamp socket. The resistor itself is *completely insulated in moulded bakelite* and sealed in metal (U.S. Pat. No. 2,421,321) . . . Small space is required—units are available for mounting in 9/16" or 11/16" clearance holes.

A wide choice of optional features includes metal finishes, terminal types, lens shapes and colors, etc. Meet Military *(MIL Spec)* and Civilian *(UL* and *CSA)* requirements.

All Assemblies Are Available Complete with Lamp.

ALSO

SUB-MINIATURE
Pilot Lights



For use with tiny incandescent bulbs (T-1¾ . . . Many units available for use with sub-miniature **Neon** bulbs (NE-2D). **Two-Terminal** units are fully insulated. **Single-Terminal** units are for use on grounded circuits. Also **Dimming** and **Non-Dimming** sub-miniatures. Meet all applicable Military Specifications.

OIL-TIGHT
Indicator Lights

For heavy-duty industrial applications. Impervious to oil, water, and dust. Rugged—withstands shock and vibration. Complete series for 11/16", 1", and 1-3/16" mounting. Use incandescent lamps and — **with patented built-in resistor**— Neon lamps

SAMPLES ON REQUEST — AT ONCE — NO CHARGE

Foremost Manufacturer of Pilot Lights

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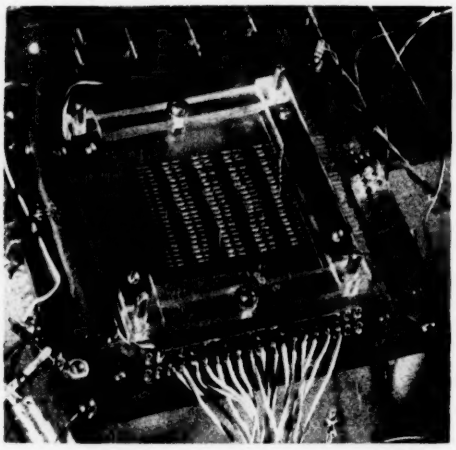
Send brochures ☐ for NE-51 Neon Lamp ☐ Sub-Miniatures ☐ Oil-Tight on Pilot Lights
Name ..... Position .....
Company .....
Address .....

For more information circle **13** on inquiry card.

NEWS—CONTINUED

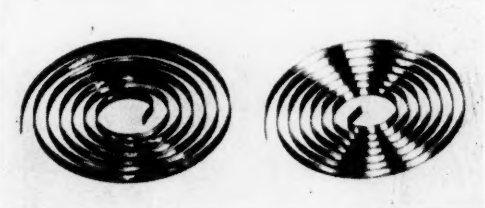


wire made of magnetic material. Torsion applied to such a wire shifts the preferred direction of magnetization from a longitudinal to a helical path. The coincidence of a circular and a longitudinal magnetic field can then be used to insert information into this wire in the form of a polarized helical magnetization, and the magnetic wire itself can be used as a sensing means.

In practice, the circular magnetic field is provided by a current pulse through the magnetic wire, and the longitudinal field by a current pulse through the copper wire which is perpendicular to the magnetic wire. Thus, storing a bit requires two coincident current pulses. One pulse by itself is insufficient to store a bit. Readout is accomplished by overdriving the longitudinal field in the reverse direction. The readout signal is sensed across the magnetic wire.

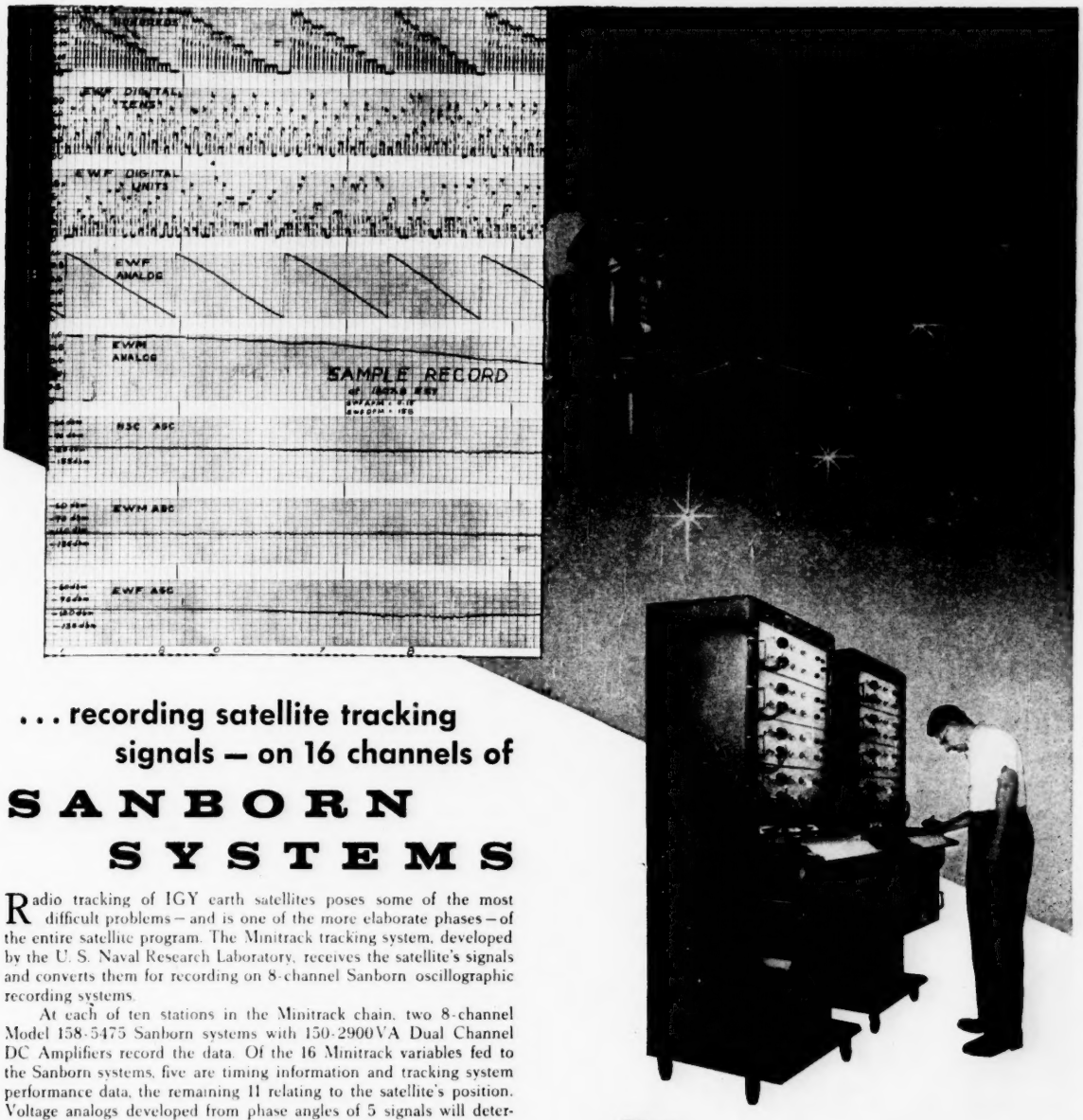
Vacuum-Heat-Treated Hairsprings

BRISTOL, CONN.—Hairsprings can control the releases of a much more powerful source of energy as in a watch or clock, they can measure varying forces as in a speedometer, the acceleration of a plane or missile, control or conduct current, record temperature, and do many other difficult jobs. Increasing performance requirements,



such as vibrations of ultrasonic frequency, very high or very low temperatures, have necessitated new materials. A newly developed spring material is Ni-Span "C," a nickel-chromium-iron-titanium alloy which has a constant modulus of elasticity over the entire temperature range from minus 75 to plus 220 deg. F.

The F. N. Manross & Sons Div. of Associated Spring Corp. has explored the possibilities of heat treating the hairsprings in vacuum with a dual-retort resistance-heated vacuum furnace. The new method has been highly successful.



. . . recording satellite tracking signals — on 16 channels of

SANBORN SYSTEMS

Radio tracking of IGY earth satellites poses some of the most difficult problems — and is one of the more elaborate phases — of the entire satellite program. The Minitrack tracking system, developed by the U. S. Naval Research Laboratory, receives the satellite's signals and converts them for recording on 8-channel Sanborn oscillographic recording systems.

At each of ten stations in the Minitrack chain, two 8-channel Model 158-5475 Sanborn systems with 150-2900VA Dual Channel DC Amplifiers record the data. Of the 16 Minitrack variables fed to the Sanborn systems, five are timing information and tracking system performance data, the remaining 11 relating to the satellite's position. Voltage analogs developed from phase angles of 5 signals will determine position. Since the analogs vary from 0-60 volts at rates up to 120 volts per second, with flyback from full scale to zero in less than 1 millisecond, the high linearity of the Sanborn recording systems becomes extremely important. Six more "position" channels will be used for digital recording — three for an "east-west" antenna pair, three for a "north-south" antenna pair. Because these recordings must be clearly readable to 1 part in 1000, each of the three channels will record tenths, hundredths and thousandths individually as shown in the actual digital recording of signals of the satellite transmitter carried in an airplane. To insure clean, easily read records, the Sanborn systems must record signals varying from 0 to 0.9 of full scale in a few milliseconds and recover from the transient in less than 15 milliseconds. The trace in the margin of the recording is serial coded timing information.

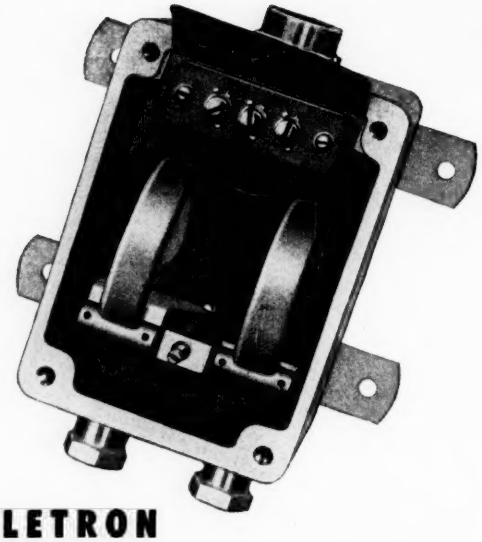
Ask Sanborn for specific recommendations on your oscillographic recording problems. Short form folder, or complete 16 page catalog, available on request.

INDUSTRIAL DIVISION
SANBORN COMPANY
175 WYMAN STREET, WALTHAM 54, MASS.

. . . recording the answers to industrial design, production and field testing problems

Flexible Sanborn "150" systems with inter-changeable plug-in Preamplifiers are solving countless measurement and recording problems in industry. Basic advantages of these systems include clear, inkless recordings in true rectangular co-ordinates; 1% linearity; choice of 13 front ends including 11 plug-in Preamps; single to 8-channel systems; console or separate case housing. For analog computer readout, extensive use is made of Sanborn "150" systems equipped with Dual-Channel DC Amplifiers (as used in the Minitrack equipment), and the compact new 6- and 8-channel "5490" and "5495" mobile console systems with the 183 Programmer for automatic control of various sequences.

For more information circle **14** on inquiry card.



MELETRON

DIFFERENTIAL SWITCH

senses pressure differences from 4 to 9000 p.s.i.

with Proof Pressures ranging from 500 to 12,000 P. S. I.

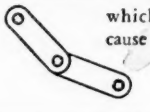
A good illustration of this switch function is its application on multiple stage compressors. If a failure occurs in one of the stages the switch will signal the pressure difference change or shut down the system to prevent damage.

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS



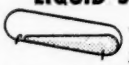
which, as they wear, cause settings to drift.

IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS



which require that the pressure switch be mounted absolutely vertical, which make it very critical to vibration.

To get complete operating characteristics and specifications ask for bulletin 532

BARKSDALE VALVES

PRESSURE SWITCH DIVISION

5125 Alcoa Avenue, Los Angeles 58, California

For more information circle **15** on inquiry card.

stock report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

New York Stock Exchange:

	Price Range for 1957 Thru December 17th High	Low	Price As Of 12/17/57
ACF Industries	04 7/8	37	39 1/4
Aeroquip Corp.	41 3/8	19 1/8	20 1/4
Allis Chalmers	36 1/4	23 1/4	21 1/8
American Chain & Cable	64 1/4	39 5/8	41 1/4
American Machine & Foundry	43 3/4	29 1/8	31 5/8
American Machine & Metals	58 3/4	41	47
American Optical	57 7/8	30 3/4	33 3/8
American Tel. & Tel.	179 7/8	160	169 1/4
Beckman Instruments	47 3/4	25 1/2	26 1/4
Bell & Howell	50 1/2	36 1/2	40 3/4
Bendix Aviation	60 3/4	42	46 1/8
Boeing Airplane	51 1/8	29	36 1/8
Bullard	29 1/8	11	10 1/4
Bulova Watch	21	10 1/4	10 3/8
Burroughs	32 3/8	30	29 1/4
Carborundum	31 1/4	28 1/4	32
Cincinnati Milling Machine	30 1/2	27 3/4	28
Clevite	25 1/2	15 1/8	15 1/4
Columbia Broadcasting A	26 1/8	23 1/2	24
Consolidated Electronics	35 1/2	18	18 7/8
Cornell Dubilier	2 1/2	14	14 5/8
Corning Glass	106 1/4	57 1/4	80
Curtiss-Wright	47 3/8	23 3/4	25 1/4
Cutler Hammer	54 1/4	28 1/2	29 1/2
Consolidated Electrodynamics	54 3/4	25 1/8	29 5/8
Dayatron	47	27 1/2	33 1/4
Douglas Aircraft	91	50 5/8	67 1/8
Eastman Kodak	115	81 3/4	93
Eaton Manufacturing	64 1/4	40 1/4	40 3/4
Electric Auto Lite	40 3/8	26 3/4	25 1/2
Elgin Watch	14 1/8	6 3/4	6 7/8
Emerson Electric	34	22 1/8	26
Food Machinery & Chemical	65 1/4	42 3/4	46
Gamewell	46 1/2	20	20 3/4
Garrett	54	23 1/4	25
General Dynamics	68 5/8	46 3/4	57 1/8
General Electric	72 3/8	52 3/8	59
General Instrument	8 1/8	4	4 3/4
General Mills	69	56	57
General Precision Equipment	47 1/4	30 1/4	32 3/4
General Railway Signal	34	19 1/2	20 3/4
General Telephone	45 1/4	36 1/4	40
General Time	30 1/2	17	16 3/4
General Tire & Rubber	30 3/8	22 1/8	27
International Business Machines	470 1/2	270 1/4	294 1/4
International Tel. & Tel.	32 1/4	27 1/4	29
ITE Circuit Breaker	50 1/8	33	39 1/4
Lockheed Aircraft	52 1/8	28	34 7/8
Litton Industries	36 5/8	20 1/2	19 1/2
Magnavox	44	26 1/4	29 1/4
Minneapolis-Honeywell	152	74 1/2	80 1/2
Minnesota Mining & Mfg.	70	58	75 1/2
Motorola	51 1/4	35 3/4	39 1/4
Mallory	30 1/4	27 1/8	27
National Acme	60 1/2	43	48
National Cash Register	70 5/8	46 1/4	51 1/8
North American Aviation	35 1/4	20 1/8	26 1/4
Northrop Aircraft	26 1/8	15 3/4	22 1/8
Otis Elevator	44 1/2	30 3/4	41 7/8
Philco	18 3/8	11	12 1/2
Radio Corp. of America	40	27	26 3/4
Raytheon	23 3/4	16 3/8	20 3/4
Rheem Manufacturing	22 1/4	12 5/8	12
Robertshaw Fulton	36 1/2	22 1/8	23 3/4
Reliance Electric	50 7/8	30 1/2	30 5/8
Sangamo Electric	39 3/4	29 1/4	34 - 34 1/2 (1)
Sperry Rand	26 1/8	17 7/8	18 1/8
Square D	35 3/4	21	21 1/8
Standard Coil Products	9 3/8	5 3/4	6 1/4
Starrett (L.S.)	65 1/2	59	59 1/2
Stewart-Warner	42 5/8	26	27 1/4
Sylvania Electric	46 1/4	30 1/2	30 3/8
TelAutograph	8 3/4	3 7/8	4
Texas Instruments	31 1/2	15 7/8	23 1/2
Thompson Products	49 3/4	46	47 1/8
Tung-Sol Electric	37 1/2	23 3/8	23 3/4
Underwood Corp.	33 1/4	14 1/4	13
Union Carbide & Carbon	124 1/2	90	90
United Shoe Machinery	45 7/8	32 1/8	32
Western Union	20 3/8	14 1/2	14 3/4
Westinghouse Air Brake	33 1/8	19 1/8	18 3/4
Westinghouse Electric	66 5/8	52 3/8	60 1/2
Worthington Corp.	66 1/2	45 1/8	46 1/8

(1) Not Traded - Bid - Asked

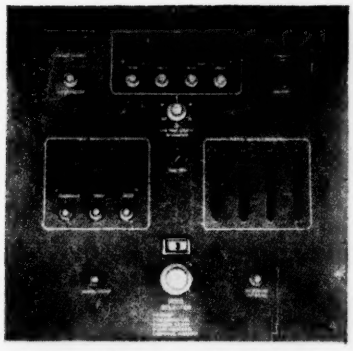
American Stock Exchange:

	Price Range For 1957 Thru December 17th High	Low	Price As of 12/17/57
American Meter	34 1/8	26 1/8	26 1/8
Ark-Equipment	22 7/8	17 1/4	14 3/4

Continued on page **18**

Kybernetes data handling equipment proven 99.7% reliable by 37,851* hours of in-plant performance!

* covering the 12 installations made during the past year.



Unmatched accuracy and reliability are achieved and sustained in the Kybernetes Data Handling System by the incorporation of advanced, fully proven techniques. The Kybernetes System provides a new, all electronic concept for the acquisition of process or test information for logging, monitoring and computing. This equipment is designed for accuracies of 0.1% for all inputs, including non-linear types, over extended periods of operation.

The Kybernetes all electronic approach to data handling provides the most direct means of digitizing low level inputs. Discrete counts, proportional in number to the magnitude of the input variables, are stored in digital form ready for direct reading into the printer or display panel. Complex analog to binary encoding and subsequent binary to digital decoding are completely eliminated.

Components having marginal operating characteristics are eliminated from Kybernetes' Data Handling Equipment, which contains no servos, stepping switches or other mechanical operations.

FEATURES OF KYBERNETES DATA SYSTEMS INCLUDE:

A — Provision to record sequential or simultaneous readings of any quantity of inputs.

B — Chopper amplifier with exceptional frequency response, linearity and gain stability as well as high noise rejection and true isolation of input and output circuitry.

C — Individual, hermetically sealed plug-in relay switching providing reliable long term commutating of input signals.

D—Specially developed linearization techniques whereby the generated comparison voltage is characterized to conform exactly to the individual non-linear characteristics of the different types of variables.

E—Plug-in, hermetically sealed components to conform to Class I, Division II requirements for semi-hazardous areas and to provide for ease of maintenance and service.

ON REQUEST: Authoritative Technical Bulletin 108a fully describes latest logging, monitoring and computing equipment. Write for free copy.

KYBERNETES®

Data Handling Equipment for Industry
logging/monitoring/computing

THE KYBERNETES CORPORATION 9 East 40th Street, New York 16, N. Y. Division of Self Winding Clock Co., Inc.

For more information circle **16** on inquiry card.

It's easy to multiply with

PREMIER

Heavy-Duty Cabinet Racks FOR MULTIPLE INSTALLATIONS

18" AND 24" DEEP

FOR STANDARD 19" WIDE PANELS

SEND FOR CATALOG IA

- Each unit consists of 1 frame and 2 doors.
- 3 panel space heights available — 61¼", 70" and 77".
- Doors hinged for either left or right hand opening.
- Sides are detachable for multiple assembly.
- 3/16" adjustable panel mounting angles.
- Finished in either Black or Gray wrinkle, Gray or Brown Hammertone.

PREMIER METAL PRODUCTS COMPANY

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WESTERN SALES OFFICE: 1485 Bayshore Blvd., San Francisco 24, Cal. Tel. JUniper 7-8700

EXPORT DEPARTMENT: EMEC 127 Grace Street, Plainview, N. Y. Tel. WEIls 1-3701

For more information circle **17** on inquiry card.

American Stock Exchange

Continued from page 16

Nelco Instrument	13 1/8	7 7/8	8
Neptune Meter	8 1/2	5 1/8	7 1/4
Breeze Corp.	8 3/8	5 1/8	5
Narry Cont. B	12 3/4	4	4
Park Controller	41	14 3/4	15
Parsetat Mfg	5	2 1/2	3
Parv Corp.	4 7/8	2 5/8	2 1/2
Pubmt Laboratories	5 1/8	3	3 1/4
Pyramids Corp. of America	3 5/8	2 1/8	2 1/4
Electronics Corp. of America	12 5/8	4 1/2	5
El-Chemite	3 7/8	1 1/2	1 1/4
Fairchild Camera & Instrument	27 3/8	15	15 5/8
Globe-Union	20 3/4	16 3/8	17 1/8
Haydite Corp.	44 1/2	29 3/4	30
International Resistance	6 1/8	3 7/8	4
Lear, Inc.	8 3/4	4 1/8	4 1/8
National Research	26 1/8	12 1/8	14 1/4
Neptune Meter	13 1/2	14 7/8	14 5/8
New Haven Clock	4 1/2	1/8	5/16
Norden-Ketay	11 3/4	3 1/4	3 3/4
Nuclear Corp. of America A	3 3/4	3/4	1 1/4
Pneumatic Scale	34	16	(1) 18 1/4 - 19 1/4
Servo Corp. of America	8	3 1/2	(2) 4 1/8 - 4 7/8
Servomechanisms	23 5/8	6 1/8	7 1/8
Wallace & Tiernan	31 7/8	21 1/4	25 1/4
Waltham Prec. Inst. Co.	3 1/4	1/4	3/4

1 - Not Traded - Bid - Asked
2 - Not Traded - Bid - Asked

Over-The-Counter

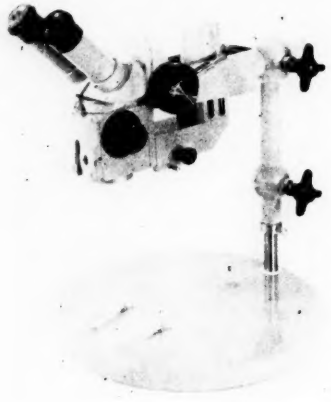
Quotation as of 12/11/57

	Bid	Asked
Aerovox Corp.	3 1/4	3 7/8
Aircraft Radio Corp.	21 1/2	22 3/4
Argus Corp.	13 1/2	14 1/4
Bitel-McCullough Co.	21 1/2	22 1/2
Electronics Associates	45	50
Erie Resistor Corp.	5 5/8	7 1/8
G.M.Giannini	13 3/4	15 1/8
Liquidometer Corp.	5	5 1/2
J.I. Maxson	5	5 5/8
Penn Controls, Inc.	12 3/4	13 3/4
Sperr Carbon, Inc.	24	24 1/4
Sprague Electric	25	25 1/2
Taylor Instrument	24	41
Telecomputing Corp.	3 3/8	3 3/4
Topp Industries	9 5/8	10 1/4
Varian Associates	16 3/4	17 5/8
Vitro Corp. of America	16 1/2	17 1/8

CARL ZEISS

STEREO TECHNOSCOPE

MADE IN WEST GERMANY



A new, modern stereoscopic binocular microscope eminently suited for industrial inspections and examinations.

Intense illumination parallel with line of vision. Erect, plastic image even in deep cavities.

Free working distance of 8 inches. Magnification changing device provides rapid succession of 6.3x, 10x, 16x, 25x and 40x magnifications.

Write for literature

CARL ZEISS, INC., 485 Fifth Avenue, New York 17, N. Y.

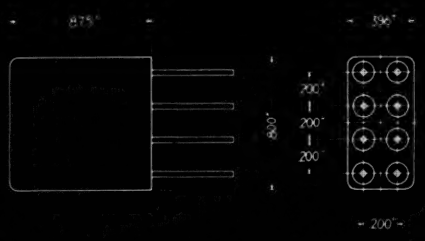
Guaranteed uninterrupted repair service

For more information circle **18** on inquiry card.

Smaller than a postage stamp!

except in thickness, of course

—the *new* CLARE *Type F* RELAY



SPECIFICATIONS

Ambient Temperature	—65° C to +125° C.
Shock	50 Gs for 11 milliseconds.
Vibration	5-75 cps at maximum excursion of ⅛-inch, 75-2000 cps at 20 Gs acceleration.
Dielectric Strength	Sea level—1000 volts rms between terminals and frame, and between adjacent circuits; 750 volts rms between contacts of a set. At 80,000 ft., 350 volts rms.
Insulation Resistance	1000 megohms minimum at 125° C.
Coils	Coils up to 10,000 ohms available for a wide range of voltages or currents.
Nominal Operating Power	250 milliwatts.
Pickup Time	3.5 milliseconds nominal.
Dropout Time	1.5 milliseconds nominal.
Contact Arrangement	2 pdt (2 form C).
Contact Rating	3 amps resistive at 28 volts d-c or 115 volts a-c; also for low-level applications.
Contact Resistance	0.050 ohm maximum.
Contact Life	500,000 operations minimum at 2 amps; 100,000 operations minimum at 3 amps.
Enclosure	Hermetically sealed, filled with dry nitrogen at 1 atmosphere pressure.
Mounting	All popular mounting arrangements available.
Terminals	Printed circuit; solder; plug-in (matching socket available). Variations of printed-circuit terminal length on 1/10-inch grid spacing available.
Weight	17 grams.
Military Specifications	MIL-R-25018; MIL-R-5757C, except as to contact overload.

This new hermetically sealed relay—no bigger than a postage stamp—is Clare's response to the insistent demand of the military and of industry for a smaller and lighter relay stalwart enough to withstand extremes of temperature, heavy shock, and severe vibration, yet fast and more than moderately sensitive.

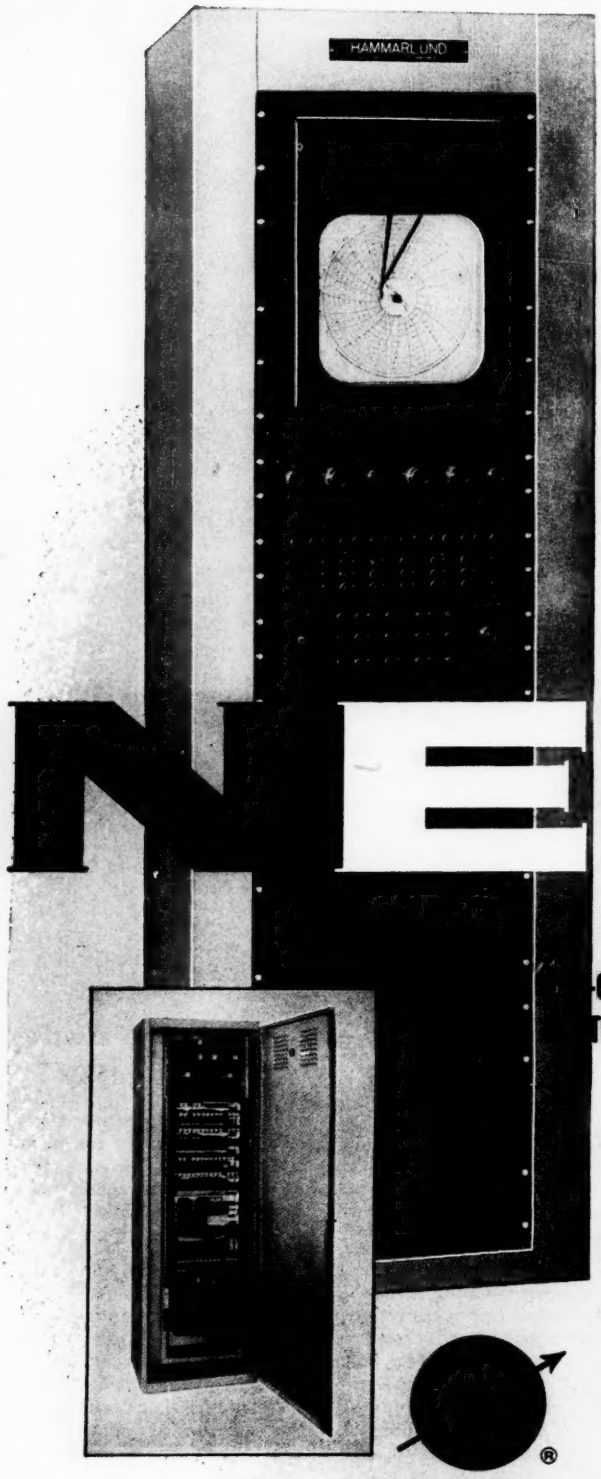
Without any assertions of superior design, materials or workmanship, the factual specifications at the left tell how closely this relay is geared to the needs of today's advanced circuit designers. Important to many engineers will be the fact that the contacts—rated at 3 amperes—are proven also for low-energy-level circuit applications. Designers of printed-circuit layouts will note that the terminal arrangement is nicely suited to 1/10-inch grid spacing.

For complete information send for Bulletin 124. Write or call: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY.

CLARE RELAYS

FIRST in the industrial field

For more information circle **19** on inquiry card.



HAMMARLUND

PULSE WIDTH SELECTOR System

NEW!

-COST SYSTEM FOR MULTI-POINT AND TI-STATION TELEMETERING AND REMOTE CONTROL

Another milestone in Hammarlund's practical approach to transmission of telemetering and remote supervisory control functions.

Now, for the first time, you can incorporate all the inherent advantages of Pulse Width Selection in your system at the very lowest initial and operating costs. The Hammarlund PWS system permits a practically unlimited number of functions, via coded pulses, either DC or audio tones to be transmitted over a single, common carrier.

PWS may be used as a two-way system for supervisory control, or it may be used as a one-way system for either control or supervision only. The maximum number of points which the standard PWS system can handle is 430 on/off control functions plus 430 supervisory functions.

A built-in, self-checking feature of the PWS results in an unusually high degree of reliability. The use of PWS is important in systems requiring savings in spectrum space on the carrier.

If you are cost-conscious, and still want the best—send for complete technical details on the new Hammarlund PWS system. . . .

Established 1910

HAMMARLUND

MANUFACTURING COMPANY, INC.

460 West 34th Street, New York 1, N.Y.

For more information circle **20** on inquiry card.

Atomic Industry Forum reports that in 1957 the U.S. atomic industry completed 16 nuclear reactors (7 power and 9 research) for private and government purchasers here and abroad. Power types included ship propulsion and prototype power plants. In addition, 59 reactors are underway, (35 power type and 24 research and test). Also in 1957, contracts for 7 uranium ore processing mills were signed, 13 companies announced plans to enter field of fuel element production and research, 3 zirconium plants were completed, as were 2 beryllium plants.

Scientific instrument industry will face narrowed profit margins and shrinking capital expenditures in 1958, says Kenneth Andersen, Executive V. P., SAMA, who estimates dollar volume for scientific instruments in 1958 will be down 5 to 15%. Increased Federal funds. for science teaching facilities will help, but will not be available until after July, 1958.

Transistors were invented in 1948; 600,000 were made in 1953; nearly 2 million were made in 1954; 5 million in 1955; 13 million (worth about $37 million) in 1956; 1957 transistor market is expected to be $70 million.

Semiconductor diodes and rectifiers grew from $7 million in 1953 to $40 million in 1956. Total semiconductor market in 1957 (transistors plus rectifiers) is about $140 million; 1958 is expected to reach $200 million; 1967 market is projected to be $1 billion.

Total electronic equipment market in 1957 is about $7 billion; H. B. Fancher, G. E. Mgr. of Semiconductor Products says market will be $12.5 billion in 1967. Further, at present only about 12% of electronic equipment now uses transistors; this will increase to 80% by 1967. There are now about 40 manufacturers of semiconductors.

Submarine telephone cable service around the world is technically possible, as evidenced by the inauguration of service between Honolulu and San Francisco, via two cables of 2200-mile length each. Almost half the cable was made by British firms, and the cables were laid by British ships.

British electronics industry exports 60 million pounds ($168 million) annually, but only 3.2 million pounds ($9 million) comes to USA. British are turning attention to American market.

Superior

CAN SUPPLY YOU WITH SMALL TUBING IN AN UNUSUALLY BROAD RANGE OF MATERIALS

OVER 100 ANALYSES TO CHOOSE FROM

Superior offers the widest variety of tubing materials in the small diameter tubing industry. You can design and specify the *right* material for the service requirements of its end application. The materials listed are classified as STANDARD or SPECIAL. Standard materials are available in any desired quantity under normal mill production delivery lead times. Special materials are produced against customer orders; it may be necessary to secure raw stock for the order, as the supplies of special analyses are limited.

MANY SIZES AND SHAPES

Tubing sizes range from .010 to 1⅛ in. OD (above ⅜ in. OD the tubing is produced with light walls of .035 in. maximum thickness). Superior has always specialized in producing tubing to the most rigid specifications. It will meet a wide variety of requirements —ability to withstand vibration and shock, high temperatures, high pressure surges—and can offer ductility, light weight with high strength, and high temperature corrosion resistance. All Superior tubing is clean, smooth and bright, in whatever temper specified.

TUBING SPECIALTIES

Superior has long recognized the needs of industry for special tubing to meet sets of clearly defined service conditions. Each class of special tubing is produced with production techniques and controls that assure optimum performance. These tubing specialties are capillary; hydraulic; fuel line; mechanical; needle; super pressure; Bourdon; structural; diesel; thermocouple; large OD thin wall; glass sealing.

For data on physical and mechanical properties, fabrication, size limitations, etc., relative to any of the standard or special analyses, write Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube
The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Co.,
5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

MATERIALS

Standard			Special		
STAINLESS STEELS					
303	316	410	202	329	420
304	321	430	301	330	440A
305	347	430Ti	304L	405	442
309	348	446	316L	416	AM350
310	403	502	317		17-7 PH[1]
ALLOY STEELS					
4130	4140	52100		1722A[2]	4615
4132	4150	.....		4340	8630
NICKEL AND NICKEL ALLOYS					
Low Carbon Nickel[3]				"D" Nickel[3]	
"A" Nickel[3]				DURANickel[3]	
Monel[3]				403 Monel[3]	
"K" Monel[3]				Inconel "W"[3]	
"R" Monel[3]				Nionel[3]	
Inconel[3]				Nimonic 75[3]	
Inconel "X"[3]				Nimonic 80A[3]	
Hastelloy "C"[4]				Inconel 702[3]	
Nichrome "V"[5]				Permalloy[6]	
Invar				Hastelloy "F"[4]	
Ni-Span "C"[5]				Hastelloy "X"[4]	
.....				Haynes 25[4]	
.....				Chromel "P"[7]	
.....				Alumel[7]	
CARBON STEELS					
C-1008	C-1025			C-1018	
MT-1010	C-1035			C-1055	
MT-1015	C-1045			C-1065	
C-1118	E-1095			.....	
MT-1020	Ingot iron			.....	
COPPER BASE ALLOYS					
30% Cupro Nickel				OFHC Copper	
Beryllium copper				Deoxidized copper	
Constantan				Berylco #10[8]	
GLASS SEALING ALLOYS					
27% Stainless (446)				.....	
42% Nickel iron				.....	
52% Nickel iron				.....	
OFHC Copper				.....	
MT-1010				.....	
Sylvania #4[9]				.....	
Kovar[10]				.....	
Rodar[11]				.....	
SUPER ALLOYS					
Type 316				A-286[12]	
Inconel "X"				19-9-DL[13]	
Nichrome "V"				Inconel 702	
Hastelloy "C"				Nimonic 75	
.....				Nimonic 80A	
.....				Haynes 25	
.....				Hastelloy "F"	
.....				Hastelloy "X"	
.....				Croloy 15-15N[14]	
.....				16-25-6[7]	
.....				Waspalloy	
.....				N-155[15]	
REACTIVE METALS AND ALLOYS					
Titanium				Zirconium	
.....				Zircaloy—2	
.....				Zircaloy—3	

[1]T.M. Reg. U.S. Pat. Off., Armco Steel Corp.
[2]T.M. Reg. U.S. Pat. Off., Timken Roller Bearing Co.
[3]T.M. Reg. U.S. Pat. Off., International Nickel Co.
[4]T.M. Reg. U.S. Pat. Off., Haynes Stellite Co., a name for its abrasion, corrosion and heat resistant alloys
[5]T.M. Reg. U.S. Pat. Off., Driver-Harris Co.
[6]T.M. Reg. U.S. Pat. Off., Western Electric Co., Inc.
[7]T.M. Reg. U.S. Pat. Off., Hoskins Mfg. Co.
[8]T.M. Reg. U.S. Pat. Off., Beryllium Corporation
[9]T.M. Reg. U.S. Pat. Off., Sylvania Electric Products, Inc.
[10]Kovar is stocked and sold through the Carborundum Co., Stupakoff Division, Latrobe, Pa.—T.M. Reg. U.S. Pat. Off., Westinghouse Electric Corp.
[11]T.M. Reg. U.S. Pat. Off., Wilbur B. Driver Co.
[12]T.M. Reg. U.S. Pat. Off., Allegheny Ludlum Steel Corp.
[13]T.M. Reg. U.S. Pat. Off., Universal Cyclops Steel Corp.
[14]Patent applied for, Babcock & Wilcox Co.
[15]Reg. U.S. Pat. Off., Union Carbide Corporation

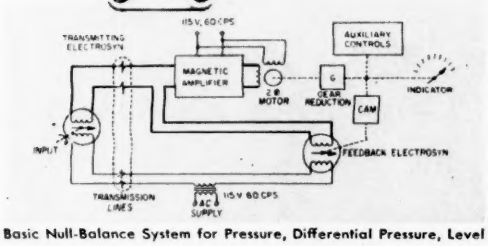
For more information circle 21 on inquiry card.

ELECTROSYN AT WORK

Leading pipe line companies are putting ElectroSyn Systems to work measuring and indicating operation pressures and flows and for digital telemetering.

Featuring high reliability, low maintenance and flexibility of application, the ElectroSyn System can withstand a static overload of 300% of rated pressure for a 1% zero shift.

Model 501



Basic Null-Balance System for Pressure, Differential Pressure, Level

Basic system consists of signal transmitter, magnetic servo amplifier, null-balance indicator. (No electron tubes, slide wires or continuously moving parts.)

In measuring pressure the Model 501 transmitter utilizes a twisted bourdon tube as the pressure sensing element. This tube converts the pressure into shaft rotation of the ElectroSyn signal generator, a rotary differential transformer. Output from the ElectroSyn signal generator is an a-c voltage exactly proportional to the measured variable.

Write for Brochure B257

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For more information circle **22** on inquiry card.

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For your convenience in passing along a good thing to an associate, we printed extra copies of this 30th anniversary - systems issue of I & A

among the men you work with, lunch with, or commute with there probably is at least one who is not now a subscriber to I & A — but who would enjoy his own FREE copy of this special January issue.

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events

January 30, 31, 1958

Seventh Annual Instrument Short Course co-sponsored by Southern California Meter Association and Los Angeles Harbor Junior College, at Los Angeles Harbor Junior College, Wilmington, Calif. For information write Thomas H. Ponton, 640 Fillmore St., Fillmore, Calif.

Feb. 3-4

ISA Symposium on Chemical & Petroleum Instrumentation, Hotel Dupont, Wilmington, Del. For information write to Mr. Bill Durkin, Fischer & Porter Co., 2011 Concord Pike, Wilmington 3, Del.

February 3-4, 1958

Flight Control—Panel Integration symposium at Wright Air Development Center, Dayton, Ohio. Write John H. Kearns, Box 942, Dayton, Ohio.

Feb. 14-15

Fifth Annual Cleveland Electronics Conference sponsored by Cleveland chapters of Institute of Radio Engineers, American Institute of Electrical Engineers, Instrument Society of America and Cleveland Physics Society, in cooperation with Case Institute of Technology and Western Reserve University, Masonic Auditorium, Cleveland, Ohio. For information write to Cleveland Electronics Conference, 14700 Detroit Ave., Cleveland 7, Ohio.

February 18

14th Annual Quality Control Clinic of Rochester Society for Quality Control, War Memorial, Rochester, N. Y.

Feb. 21

Meeting of the Gulf Coast Spectroscopic Group, Houston, Texas. For information write W. M. Padgett, Monsanto Chemical Co., Texas City, Texas.

March 10-20

Quality Control Short Course, University of Illinois College of Engineering in cooperation with the Div. of Engineering Extension at Urbana, Ill. For further information, write to Prof. John A. Henry, Rm. 205, Mechanical Engineering Laboratory, University of Illinois, Urbana, Ill.

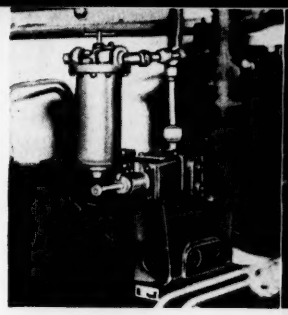
March 11-13

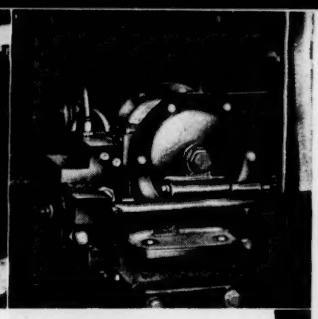
Eighth Annual Conference on Instrumentation for the Iron and Steel Industry, sponsored by Pittsburgh Section, Instrument Society of America, Roosevelt Hotel, Pittsburgh. For information contact Fred D. Marton, 845 Ridge Ave., Pittsburgh 12, Pa.

March 17-21

1958 Trade Show of the atomic energy industry, held in conjunction with the 1958 Nuclear Congress, International Amphitheatre in Chicago. For information in New York, Contact Joel

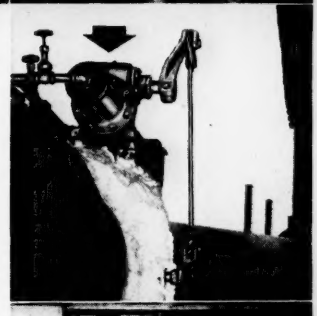
FOR
PRESSURE
•
FLOW
•
PROPORTIONING
•
COMBUSTION
•
POSITION

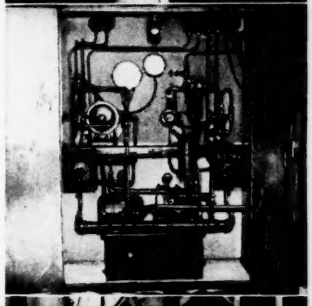


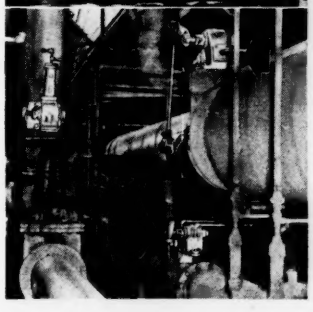


Key Component for those TOUGH CONTROL JOBS

THE ASKANIA JET PIPE RELAY







THE ASKANIA JET PIPE RELAY, nucleus of Askania Controllers for pressure, flow, proportioning, combustion and position, is designed for the TOUGH control jobs. You can depend upon it for the operation of LARGE, HEAVY valves, dampers, engine throttles and other final control elements or those having high thrust requirements.

The Askania Jet Pipe Relay provides double acting positive correcting power which opens and closes the valve without the need of a spring return.

Shown on this page are typical examples of Askania's ruggedly constructed Jet Pipe Control systems used for flow, pressure, proportioning and combustion control applications. Askania Jet Pipe Controllers:

- operate equally well indoors and outdoors—won't freeze
- operate even under the most adverse ambient conditions
- are easily installed
- require minimum maintenance
- give instantaneous response to minute changes in the measured variable

Send for General Catalog which describes and illustrates how Askania Jet Pipe Regulators can be applied to various process applications...shows you the solution to your own tough problems. Write Askania Regulator Company, 268 E. Ontario St., Chicago, Illinois

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Address inquiries to:
General Precision Equipment Corporation
92 GOLD STREET, NEW YORK 38, N. Y.
For more information circle **24** on inquiry card.

EVENTS—CONTINUED

Henry, American Institute of Chemical Engineers, 25 W. 45th St., New York 38, N. Y. In Chicago, contact J. Earl Harrington, Western Soc. of Engineers, 84 E. Randolph St., Chicago, Ill.

March 17-21

14th Annual Conference and Exhibition of the National Association of Corrosion Engineers, March 17-21, Civic Auditorium, San Francisco. For information write A. B. Campbell, Executive Secretary, National Assoc. of Corrosion Engineers, 1061 M&M Building, Houston 2, Texas.

March 26-28

20th Anniversary Meeting of American Power Conference, sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago. For information write Conference Director R. A. Buddenholzer, mechanical engineering dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

April 10-12

Tenth Southwestern I.R.E. Conference & Electronics Show, St. Anthony Hotel and Municipal Auditorium, San Antonio, Texas. For more information write Southwestern I.R.E. Conference and Electronics Show, P. O. Box 55, San Antonio 6, Texas.

April 15-17

Annual Welding Show of the American Welding Society, Kiel Auditorium, St. Louis. Write to A.W.S. Welding Show, c/o Robert T. Kenworthy, exposition management, 12 East 41 St., New York 17, N. Y.

April 22-24

Electronic Components Conference, Ambassador Hotel—Los Angeles, Calif. For information write David M. Knox, Packard-Bell Electronics Corp., 12333 West Olympic Blvd., Los Angeles 64, Calif.

May 4-7, 1958

The Fourth National Flight Test Instrumentation Symposium of the Instrument Society of America, Symposium Committee, Park Sheraton Hotel, New York City, N. Y. For information write P.O. Box #113, Bethpage, Long Island, New York.

May 6-8

1958 Western Joint Computer Conference of the Institute of Radio Engineers and the American Institute of Electrical Engineers, Ambassador Hotel, Los Angeles. For information write David Parry, 6363 Wilshire Blvd., Los Angeles 48, Calif.

May 7-17

United States World Trade Fair, New York Coliseum, N. Y. For information write to U. S. World Trade Fair, 331 Madison Ave., New York 17, N. Y.

May 12-14

Annual Symposium ("New Principles in Instrumental Methods of Analysis") of Instrument Society of America, Analysis Instrumentation Div., Shamrock Hilton Hotel, Houston, Texas. For information write ISA, c/o R. D. Eanes, Leeds & Northrup Co., Phila. 44, Pa.

May 31-June 8, 1958

European Congress of Chemical Engineering and ACHEMA Congress, Frankfurt a.m., Germany. For information write DECHEMA, Dechema-Haus, Rheingau-Allee 25, Frankfurt a.m., West Germany.

June 1-6

Ninth Annual Industrial Research Conference, Arden House, New York City. For information write 409 Engineering Bldg., Columbia University, New York 27, N. Y.

June 2-4

1958 National Telemetering Conference sponsored by the A.I.E.E., A.R.S., I.S.A. and I.A.S., Lord Baltimore Hotel, Baltimore, Md. For information write T. E. Meyers, Wolfe & Mann Mfg. Co., 28th & Sisson St., Baltimore 11, Maryland.

June 9-12

National Conference on Materials Handling sponsored by American Society of Mechanical Engineers (in conjunction with National Materials Handling Exposition), Public Auditorium, Cleveland. For information write to Banner & Greif, 369 Lexington Ave., New York 17, N. Y.

June 9-13, 1958

Fourth International Automation Exposition, Congress, Conferences, and Clinics, New York Coliseum. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

June 23-27

12th technical Photographic Exhibit in conjunction with 61st Annual Meeting and 13th Exhibit of Scientific and Testing Apparatus and Laboratory Supplies sponsored by The American Society for Testing Materials, Hotel Statler, Boston, Mass. For information contact E. W. Walsh, Chairman, ASTM Photographic Exhibit, The Narragansett Electric Co., 15 Westminster St., Providence, Rhode Island, *or* the Headquarters of the American Society for Testing Materials, 1916 Race St., Phila. 3, Pa.

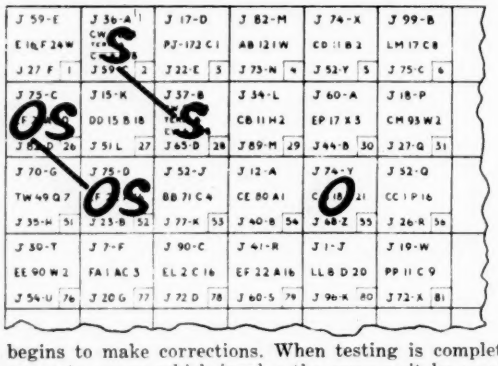
August 5, 6 and 7

1958 Special Technical Conference on Non-Linear Magnetics and Magnetic Amplifiers of The American Institute of Electrical Engineers (AIEE), Hotel Statler, Los Angeles, Calif. For information write to G. C. Anderson, Autonetics Dept. 388-64, 9150 E. Imperial Hwy., Downey, Calif.

briefs

Wiring System Testing

One of the reasons the matrix chart speeds testing is that it eliminates the necessity of correcting errors one at a time. When testing with a DIT-MCO Analyzer, the operator runs a complete test of the entire circuit before

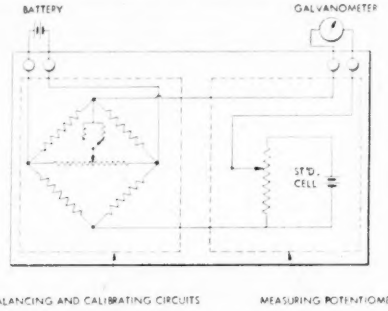


he begins to make corrections. When testing is complete, he connects errors which involve the same unit by marking on a plastic envelope which covers the matrix chart. He then makes his corrections *in groups*. In this way, he avoids returning to given connector or relay more than once . . . Electronic detector unit may be preset to pass or reject any desired value of resistance. Continuity can be closely defined to reject ½ ohm resistance as an open circuit at currents up to 2 amperes. Leakage resistance can be closely defined to the point of rejecting zero ohms to 200 megohms as a direct short . . . (*From new 22-page catalog, Dit-Mco, Inc., Electronics Div., 911 Broadway, Kansas City 5, Mo.*)

For this literature circle **201** on inquiry card.

Type C Calibrator

One of the Type C's most unique features is the comparison of voltages as a ratio. This greatly simplifies the checking of linearity of wire strain gages by eliminating tedious arithmetic involved in the use of systems that



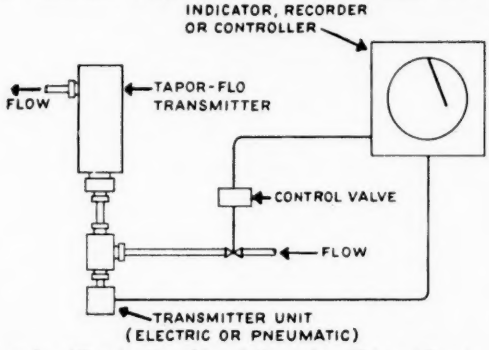
TRANSDUCER BALANCING AND CALIBRATING CIRCUITS MEASURING POTENTIOMETER

refer the voltages to the emf of a standard cell. Another unusual feature of the Type C is that all loads applied to a transducer being calibrated are read on the instrument directly in force, acceleration, etc . . . The Type C Calibrator may be employed for the electrical calibration of 1-, 2-, or 4-arm strain gage transducers. The calibration may be in terms of a parallel resistance shunted either across one arm or across two arms; or it may be in series with one arm . . . (*From new 4-page brochure, Allegany Instrument Co., Inc., 1091 Wills Mt., Cumberland, Md.*)

For this literature circle **202** on inquiry card.

Heavy-Duty Flowmeters

The Tapor-Flo meter varies the area of the flow outlet in direct relation to the rate of flow, maintaining a constant pressure differential. It does this by means of a float which rises in a precision-bore glass tube as the flow increases, proportionately exposing more of a V-

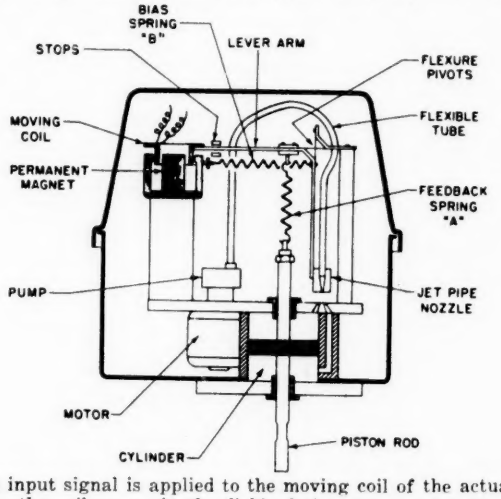


shaped orifice in the side of the tube. This orifice is accurately tapered by ultrasonic impact grinding such that float position is directly related to the rate of flow . . . The bottom edge of the float indicates the flow value on an evenly-graduated scale . . . High-low range meter can be supplied with flow tube having narrower taper on lower half of orifice, making possible measurement of extremely low flow rates on lower 50% of scale, and higher flow rates on upper 50% of scale. Stability of measurement unchanged . . . (*From new 2-page Bulletin 2010, C-MAR Corp., 35 Euclid Ave., Manasquan, N. J.*)

For this literature circle **203** on inquiry card.

Electrohydraulic Valve Actuator

Basically, the Model RF-697 Electrohydraulic Valve Actuator comprises: (1) a moving coil and permanent magnet input signal system, (2) an Askania jet pipe relay, (3) an hydraulic cylinder, and (4) an oil pump . . . When



an input signal is applied to the moving coil of the actuator, the coil moves in the field of the permanent magnet an amount proportional to the change in the input signal. The jet pipe is mechanically attached to the moving coil and consequently moves with it. As a result, the oil pressure differential across the cylinder piston is changed accordingly and the piston moves; thereby, repositioning the valve . . . . (*From new 4-page Bulletin 38.3, Askania Regulator Co., 240 East Ontario St., Chicago 11, Ill.*)

For this literature circle **204** on inquiry card.

continuously integrated total of data as it is being recorded or presented

THE LIBRASCOPE

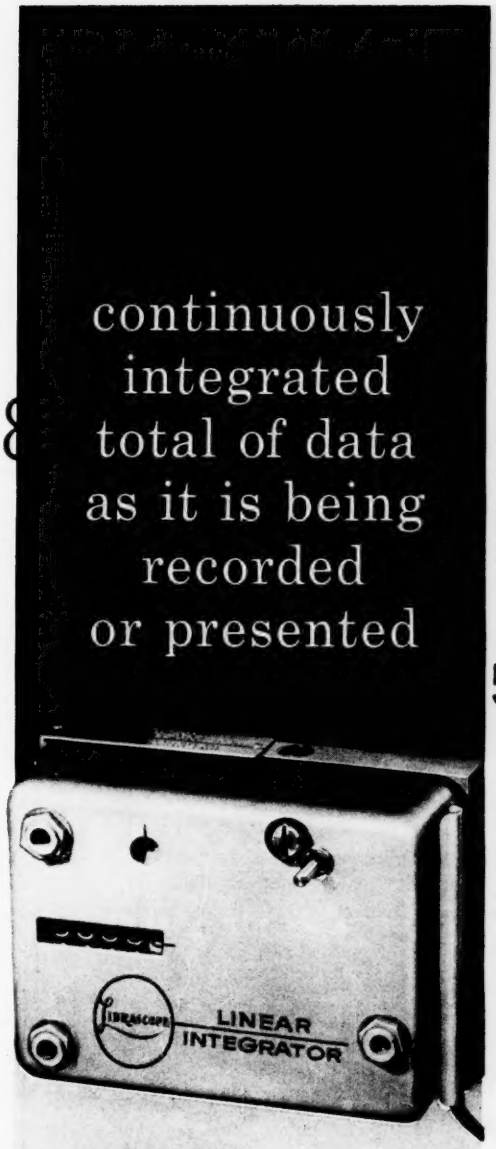
Model 25

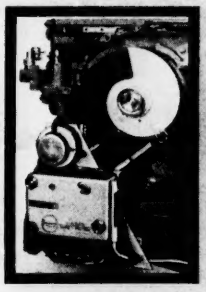
COMPUTING LINEAR INTEGRATOR

Designed for flow totalization, temperature recorder averaging or area computations in gas analysis procedure. The Librascope Model 25 is a fast, accurate computer for direct reading or remote reading through electrical impulse output.

With this Librascope unit, manual integration of recording data with its attendant inaccuracies can be eliminated.

Other desirable features include high response, low torque requirement, also low maintenance with a pulse output that provides for convenient electrical transmission for use in data systems or remote counters. Installation kits available.





Mounted on Strip Chart Recorder, the Model 25 Librascope Linear Integrator in this position accepts the output of the transducer or the recorder plus motion as an input.

Model 25

- Linearity (% of full scale) – 0.2
- Repeatibility (% of full scale) – 0.05
- Range (Percent) – –10 to +110
- Full Scale Travel – 23°, 28'
- Response – Instantaneous
- Torque
  - Time Shaft (in./or.) – 0.50
  - Input Shaft (in./oz.) maximum – 0.35
- Temperature Range – –45°F to +150°F
- Outputs: Mechanical Counter and Switch Closer For Remote Pulse
- Weight – 1.5 (lbs.)

Write for Linear Integrator Bulletin.

LIBRASCOPE

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For more information circle **26** on inquiry card.

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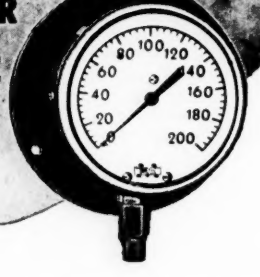

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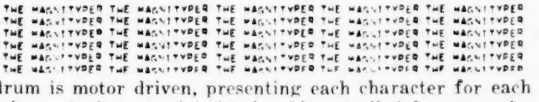
For more information circle **28** on inquiry card.

BRIEFS—CONTINUED

High Speed Printer For Data Processing

The Potter "Magnityper" is a high speed electronic printer consisting of two major assemblies: The printing mechanism and the storage-comparator system. The printing mechanism consists of a horizontally-mounted drum on which are mounted up to 120 columns of type in units of 20 characters with 63 distinctive characters in each column uniformly distributed around the drum . . . The



drum is motor driven, presenting each character for each column to its associated solenoid-controlled hammer. An inked ribbon and paper moves between the hammers and the type faces. Printing occurs when the solenoids actuate the hammers . . . The Magnistor memory system, (a magnetic logical gating element), consists of 120 six-bit modules, one for each print column. Gating of the memory by a counter system permits digital information from the input source to be stored sequentially . . . The time required for the type drum to make a complete revolution is less than 95 milliseconds, paper advance time is 15 milliseconds . . . (*From new 8-page Bulletin 892, Potter Instrument Co., Inc., Sunnyside Blvd., Plainview, N. Y.*)

For this literature circle **205** on inquiry card.

Plastic Gate Valve

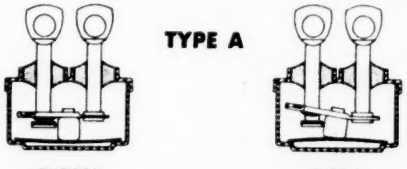
The Vanton Flex-Plug Valve combines the straight-flow, no-pressure-drop characteristics of a gate valve with the throttling flow-control features of a globe valve, plus the corrosion and abrasion resistance of plastic, here

brought together for the first time in an eminently functional and versatile valve design . . . Linear throttling control from 0 to 90% of flow plus completely unimpeded flow at fully-open position . . . (*From new 4-page Catalog 42.0, Vanton Pump and Equipment Corp., Hillside, N. J.*)

For this literature circle **206** on inquiry card.

Disc-Type Thermostats

In the Type A design, the spring of the contact arm holds the contacts in the closed position. When the Spencer disc snaps to reverse curvature, the contact arm is lifted, opening the contacts. The thermostat can be made to



open or close on temperature rise by reversing the disc . . . Switch action for both types is single-pole, single-throw with a single contact make and break . . .Temperature setting tolerance of ±5°F on both opening and closing can be provided . . . (*From new 4-page Bulletin THSN-4A, Metals & Controls Corp., Spencer Thermostat Div., Attleboro, Mass.*)

For this literature circle **207** on inquiry card.

GENERAL INSTRUMENT
SEMICONDUCTOR DIVISION
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Uniform excellence in all parameters permitting a far wider range of applications

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RESULTS IN GREATER STABILITY AND LONGER LIFE

RADIO RECEPTOR'S

silicon diode 1N658

- **HIGH FORWARD CONDUCTANCE** 100 mA @ 1V.
- **LOW REVERSE LEAKAGE** .05 μa @ −50V @ 25° C; 25 μa @ −50V @ 150° C.
- **HIGH PEAK INVERSE VOLTAGE** 120V.
- **FAST REVERSE RECOVERY** 80K ohms in .3 μsec.*
- **HIGH OPERATING TEMPERATURE** 175° C.

*When switching from 5 mA to−40V. RL = 2K. CL = 10 μμf.

RATINGS

Maximum inverse working voltage: 100V.
Average forward current: 200 mA.
Maximum power dissipation: 200 mW.

Latest achievement of the GI team of semiconductor specialists is this universal silicon diode 1N658. Radio Receptor's newly developed process combines in skillfully balanced proportion every desirable characteristic you've sought in silicon diodes. Result is a fully reliable component that does a better job in almost every standard application.

In addition to the 1N658, Radio Receptor offers to the industry a full range of RETMA subminiature silicon diode types to meet other applications. Full information is available upon request to Section A-1.

RRco. 1N658 is available now in production quantities for immediate delivery from our factory. Small quantities for testing and evaluation can be purchased from any authorized RRco. distributor and orders sent direct to Radio Receptor will be handled promptly.

RADIO & ELECTRONIC
RR
PRODUCTS SINCE 1922

Semiconductor Division
RADIO RECEPTOR COMPANY, INC.
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Germanium & Silicon Diodes • Dielectric Heating Generators and Presses
Selenium Rectifiers • Communications, Radar and Navigation Equipment

For more information circle **29** on inquiry card.

MADE FOR INSTRUMENTS & CONTROLS

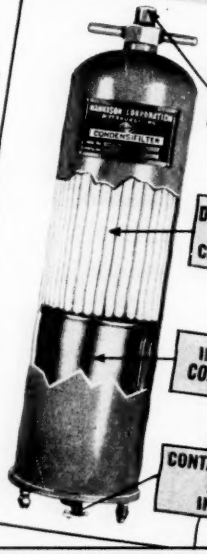
THE HANKISON Condensifilter

for "I.Q.*" Compressed Air

* the ONLY SINGLE UNIT that delivers "Instrument-Quality Air"

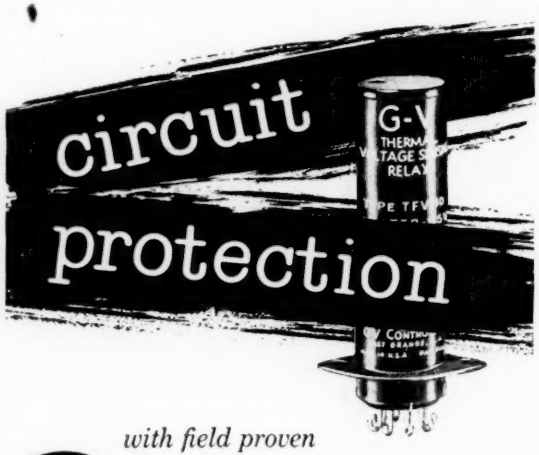
- MAXIMUM CONDENSATION
  Air is cooled to within 2° of cooling water
- DISPOSABLE FILTER CARTRIDGE
  Removes dirt, sludge, oil and other foreign matter
- RUGGED CONSTRUCTION
- LOW MAINTENANCE
  Needs only 1 HOUR PER YEAR servicing
- RATED CAPACITY
  100 scfm at 100 psig

Write for Bulletin M-7155



HANKISON CORPORATION
College & Pike • Canonsburg, Pa.

For more information circle **30** on inquiry card.



with field proven

G-V **THERMAL SENSING RELAYS**

G-V Sensing Relays operate contacts when current or voltage to their heaters exceeds or drops below the operating point. They can be selected with a response rate paralleling the action of the equipment. These relays operate quickly on heavy changes but tolerate slight changes until they become dangerous.

Meets military requirements

Write for Engineering Assistance and complete technical Data. Ask for Publication 70.

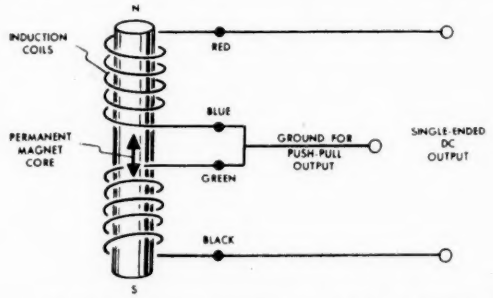
G-V **G-V CONTROLS INC.**
60 Hollywood Plaza, East Orange, N. J.

For more information circle **31** on inquiry card.

BRIEFS—CONTINUED

Linear Velocity Transducers

The Sanborn LVsyn consists of a magnet core which moves concentrically within a shielded cylindrical coil. Since the core is a permanent magnet of high coercive force, a sizable d-c voltage is induced in the coils. The



generated voltage varies exactly linearly with core velocity, and the LVsyn has infinite resolution . . . Tapped holes in each end of the magnet core allow simple coupling to the moving system being measured. Low friction can be achieved since no mechanical connection is required between core and coil . . .(*From new 4-page bulletin, Sanborn Co., Industrial Div., 175 Wyman St., Waltham 54, Mass.*)

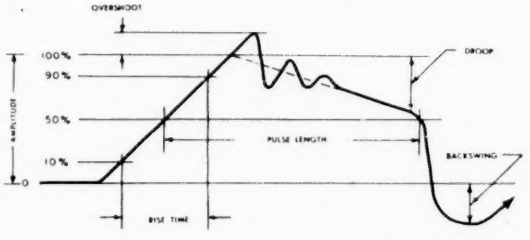
For this literature circle **208** on inquiry card.

Pulse Engineering

Rise Time—Time required for the pulse amplitude to increase from 10 percent to 90 percent amplitude.

Pulse Width—Duration in microseconds between the intersections of the 50 percent amplitude line with the leading and trailing edges of the pulse.

Figure 1 and the accompanying definitions describe the terms used in this catalog as referred to pulse transformers



Overshoot—Amplitude of the first maximum excursion of the pulse beyond the 100 percent amplitude level expressed as a percentage of this 100 percent amplitude.

Backswing—Amplitude of the first maximum excursion in the negative amplitude direction after the trailing edge of the pulse, expressed as percentage of the 100 percent amplitude . . . These definitions describe the terms used in this catalog . . . (*From new 12-page Catalog C 201, Pulse Engineering, 2657 Spring St., Redwood City, Calif.*)

For this literature circle **209** on inquiry card.

Solion

The solion's sensitive reaction to low-energy stimuli and the extremely low power required for its operation make it particularly attractive in remote and unattended devices. A plastic housing contains electrodes and electrolyte in a configuration designed to convert alternating mechanical pressure into an electrical output that is proportional to the pressure input. In the static state,

Continued on Page 38

when you have

ken ✻

you can!

ESC HAS THE KNOW-HOW AND EXPERIENCE REQUIRED TO PRODUCE CUSTOM-BUILT DELAY LINES TO YOUR EXACTING SPECIFICATIONS.

1st in sales!

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Exceptional employment opportunities for engineers experienced in pulse techniques.

CORPORATION

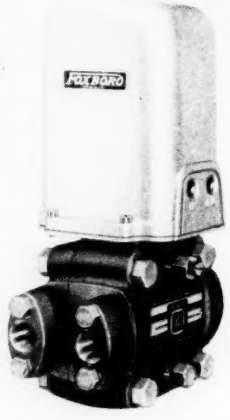
534 Bergen Boulevard, Palisades Park, New Jersey

For more information circle **32** on inquiry card.

GET THE BEST SOLUTION TO EVERY FLOW

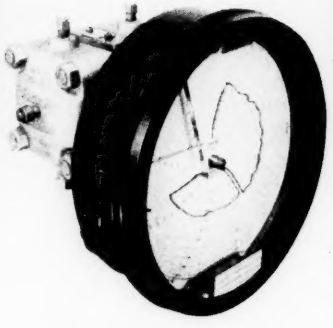
Differential Pressure Cell Transmitters

Complete line includes air-operated and electric-operated d/p Cell Transmitters covering ranges from 0-20" to 0-850" of water; working pressures up to 4000 psi.



Type 13A d/p Cell Transmitter

- Positive Overrange Protection—up to full 1500 lbs. rating
- Fully Adjustable Ranges—0-20" to 0-850" water
- Automatic Internal Damping — fast, stable measurement
- Simplicity—easiest, lowest-cost installation, lowest maintenance



Type 37 Diaphragm Meter

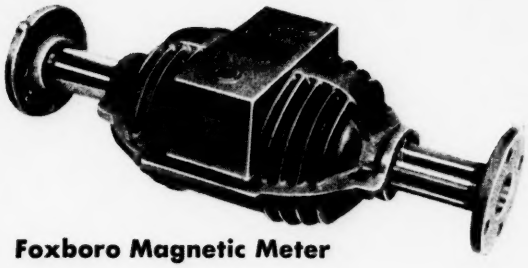
- Uses no mercury
- Positive overrange protection at static pressures up to 2000 psi
- Exclusive Features — Built-in temperature compensation never needs change or adjustment; twin-spiral range springs readily accessible for easy range changing
- Unique packless drive bar transmits linear motion to pen arm
- Ranges of 20", 50", 100", 200"; available in round or rectangular cases; 316 stainless or carbon steel body

PROBLEM

THERE ARE two logical reasons why Foxboro Instrumentation assures you optimum results in measurement or control of process fluid streams. First: Foxboro offers the widest variety of measuring and controlling devices . . . the right equipment for every application. For example, only Foxboro offers all these basic meter types: differential pressure cell flow transmitters, magnetic meters, mercury meters, and weir meters. Second: Foxboro provides 45 years of engineering experience in every phase of fluid mechanics.

From the simplest general utility-type instrument to complex automatic ratio control systems, you get highest accuracy, efficiency, and economy. Whenever you have a flow problem involving liquids, vapors, gases or slurries — in pipes, ducts, or channels, you can solve it best by specifying Foxboro.

Only a few instruments are described on these pages. For full details, or for specific information on your problem, contact your nearby Foxboro Field Engineer, or write **The Foxboro Company, 461 Norfolk St., Foxboro, Mass.**



Foxboro Magnetic Meter

- **Measures Fluid Velocity Directly**
- **Adds No Pressure Drop**
- **Uniform Flow Scale**
- **Overall Accuracy Better than 1% of Range Over Entire Scale**
- **Full Accuracy Sustained Even on Liquids Other Meters Can't Handle — even sand and water slurries**

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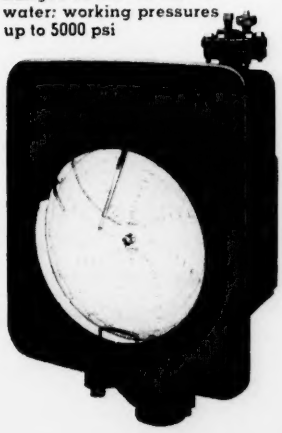
***FIRST* IN FLOW**

Mercury Type Meters

- Permanent Full-Scale Meter Accuracy — exclusive segmental lever design provides linear transmission from float to pen
- High-Powered Pen Drive—large float with long travel
- Minimum Ambient Temperature Effects — float located in high pressure chamber
- Ranges from 2" to 400" of water; working pressures up to 5000 psi



Other Foxboro Flow Instrumentation

Float-and-Cable Type Meters

Electric or Pneumatic Type Rotameters

Electric, Pneumatic, and Mechanical Integrators

Planimeters

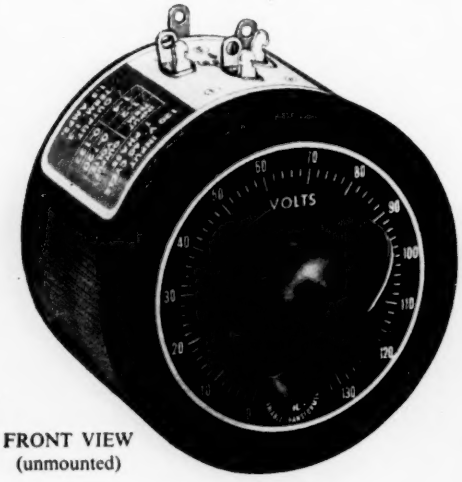
All Primary Elements, Valves, and Accessories required for complete flow measurement and control systems

For more information circle **33** on inquiry card.

INDUSTRY'S MOST ADVANCED DESIGN!

(Patent No. 2,790,882)

OHMITE®
V.t.
VARIABLE Transformer

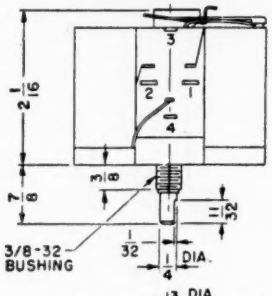


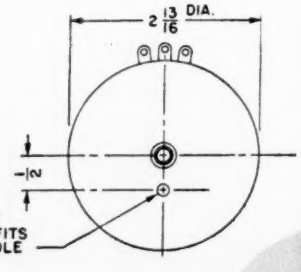
FRONT VIEW
(unmounted)

MORE CAPACITY FOR EQUAL SIZE

MODEL VT1R5—1.5 AMPERES. The rating of 1.5 amperes represents a continuous current rating at any brush setting even at full overvoltage! This "bonus" in current capacity is the result of a unique core design by Ohmite. This new component from Ohmite is made to the same high standards as the famous Ohmite resistors, rheostats, and other components. Other models in larger sizes will be announced soon.

Direct reading dial is calibrated to 120 on one side—132 on the other, for line or overvoltage connections respectively.





In addition to its greater capacity for equal size, the new Ohmite VARIABLE TRANSFORMER, representing industry's most advanced design, features the following quality features:

- *Heavily Plated Rhodium Brush Track* . . . Generous, nonoxidizing plating assures unsurpassed life under demanding conditions.
- *Positive Current Transfer* . . . The contact arm carries no current in this unit! A pigtail shunts the current from the brush, directly to a large copper-graphite slip ring which contacts a large area of the terminal. The spring-like contact arm provides its own completely independent pressure.
- *Rugged INTERNAL Stop* eliminates possibility of damage to contact arm and brush due to application of torque at rotation limits.
- *Ceramic Hub* . . . Mounts and aligns the contact arm, provides 3000 volts ac insulation between parts at line potential and shaft.

AVAILABLE FROM STOCK:
SPECIFICATIONS—MODEL VT1R5
INPUT VOLTAGE—120V, 60 CYCLE.
MAX. OUTPUT AT ANY BRUSH SETTING—1.5 AMPS. OUTPUT VOLTAGE—0-132—0-120.
ANGLE OF ROTATION—320°.
Includes knob, reversible dial plate, washer and nut.
Tandem assemblies available soon.

BACK VIEW

WRITE FOR BULLETIN 151

OHMITE *V.t.* VARIABLE TRANSFORMER

OHMITE® QUALITY Components

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS • VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3615 Howard Street, Skokie, Illinois

For more information circle **34** on inquiry card.

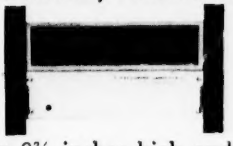
LOADING OR UNLOADING SPEED:

14 μ SEC/CHARACTER

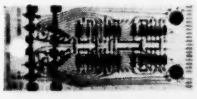
144-BQ8 CORE MEMORY

1075 FERRITE CORES

A SMALL, TRANSISTORIZED UNIT FOR SYSTEM COMPATIBILITY IN: data processing, computing and automation systems. Another member of Telemeter Magnetics' growing family of coincident current magnetic core storage buffer units, this neatly designed package containing storage capacity for 1152 binary digits, switching and driving circuitry to load and unload information and a self-contained power supply, measures only 8¾ inches high and 14 inches deep in standard relay rack mounting. Like the larger Telemeter Magnetics buffers, it is designed to provide compatibility between two data systems having different operating characteristics. Pioneer work in the development and manufacture of magnetic core storage buffers has made Telemeter Magnetics a specialist in this field. Call them in to solve any memory or buffering problem, or for specific information regarding the 144-BQ8 or the 1092 series of buffers, write:



0/1 TELEMETER MAGNETICS *Inc.* 2245 Pontius, Los Angeles 64, California



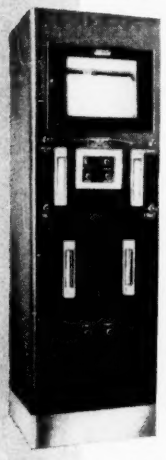
For use as: delay, temporary storage or buffer, specify the **144-BQ8**

SPECIFICATIONS: Number of characters: 144; Number of bits/characters: 8*, loaded or unloaded simultaneously; Loading or Unloading Speed: 14 μ sec/character; Solid state components only. Signal Amplitudes: Input: ZERO—5 Vdc, ONE+5 Vdc, Output: Pulse: ZERO—5V, one +5v. Load Sync: +10v, Unload Sync. +10v. Power: 1 amp at 115v, 60 cps.
**Available in 4 bit model, specify 144-BQ4*

For more information circle **35** on inquiry card.

GOW-MAC THERMAL CONDUCTIVITY
GAS ANALYZERS

—for GAS PURITY, GAS MIXING AND PROCESS CONTROL OF



Argon
Carbon Dioxide
Deuterium
Ethylene Oxide
Freon (Genetron)
Helium
Hydrogen
Ortho-Para Hydrogen
High Energy Fuels
Nitrogen
Oxygen
Special Atmospheres
— And Many Others

Other Gow-Mac Analyzers include:

GAS BLENDER — For quality control, oxygen or hydrogen burn-out and uniform quality of cylinder mixes and cascades.

"GAS MASTER" — For closely linked laboratory systems. Has all components in a single package.

GAS CHROMATOGRAPHY CELLS — Hot Wire and Thermistor Types

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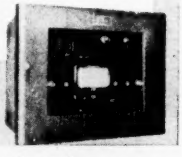
NEW CATALOG AVAILABLE — Call or write for Bulletin TC TH-12-57

Please address inquiries to Dept. IA



GOW-MAC INSTRUMENT CO.
100 Kings Road, Madison, N.J.
Telephone: FRontier 7-3450

For more information circle **36** on inquiry card.

Surface
PYROMETERS
for every purpose

The routine use of CAMBRIDGE Surface Pyrometers takes the guesswork out of temperature determination in many industries. The CAMBRIDGE is accurate, dependable, rugged, quick-acting and easy to use. The Roll Model is for checking surface temperatures of moving rolls. The Needle Model is for insertion into materials in a plastic or semi-plastic state for batch temperature determination. The Mold Model is for checking surface temperatures of mold cavities and surfaces of almost any contour.

Send for Bulletin 194SA.

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CAMBRIDGE
PIONEER MANUFACTURERS OF
PRECISION INSTRUMENTS

Moisture Indicators and Recorders • Physical Testing Instruments Laboratory Instruments for A.C. and D.C. • Galvanometers • Engineering Instruments • Gas Analysis Equipment • Physiological Instruments and many other Mechanical and Electrical Instruments

For more information circle **37** on inquiry card.

BRIEFS —CONTINUED

iodine in solution in the vicinity of the orifice cathode is reduced, acquiring electrons from the cathode metal, while iodine in the vicinity of the anodes is oxidized, giving up electrons to the anode metal. This establishes a small static current through the external circuit, called the diffusion current, and it is limited by the electrode area and diffusion coefficient of the iodine. If an alternating pressure is imposed on the diaphragms, the electrolyte will be pumped through the orifice, bringing new ions

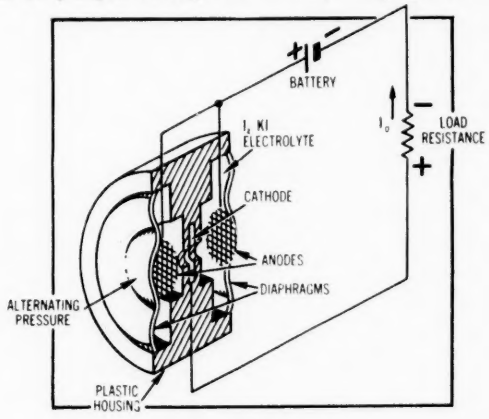


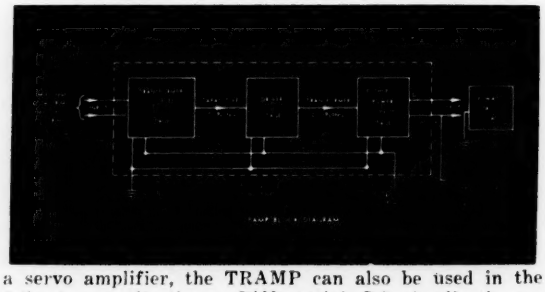
FIG. 1 SCHEMATIC CROSS-SECTION OF SOLION ENERGY TRANSDUCER

into the vicinity of the cathode and causing a correspondingly large increase in the current through the external circuit. Solions . . . are inherently low-frequency devices, usually operating best in a range from a small fraction of a cycle per second to 10 or 20 cps. This limitation is an advantage in systems whose basic frequency is a small fraction of a cycle per second, since vacuum tube and transistor amplifiers usually will not operate at these frequencies without the addition of such complications as chopping, modulation or direct coupling . . . (*From new 4-page Eng. Bulletin No.* 1, *Nov.*, 1957, *National Carbon Co., Div. of Union Carbide Corp.*, 30 *E.* 42 *St., New York* 17, *N. Y.*)

For this literature circle **210** on inquiry card.

Servo Amplifiers

The basic function of these transistor servo "TRAMP" amplifiers is to provide up to 9 watts controlled power for the operation of standard servo motors in response to AC input signals . . . In addition to its basic function as



a servo amplifier, the TRAMP can also be used in the following applications: Differential DC Applications—addition of a transformer coupled demodulator permits operation of DC devices such as friction clutches, brakes, hydraulic valves, etc. Magnetic Amplifier Applications—provides direct control of high-powered AC magnet amplifiers for synchro control of large high-watta servo-motors. Relay Applications—less than 10 millivol signal can operate a DC or AC relay . . . (*From new* 4-*page Form* 1800, *M. Ten Bosch, Inc., Pleasantville, N. Y.*)

For this literature circle **211** on inquiry card.

MAINTENANCE-FREE

INDEFINITE STORAGE

HIGH PEAK CURRENTS

HERMETICALLY SEALED

LONG LIFE

NON-GASSING

SINTERED PLATES

the new miniature rechargeable nickel cadmium

BUTTON · CELL

BATTERY

Gulton Button · Cell batteries are available in capacities of 250 and 500 milliampere hours. Each Button · Cell has a nominal capacity of 1.2 volts. Multiple cells are packaged in any desired voltage combination to meet your specifications.

The Button Cell is only one of a complete line of nickel cadmium, nickel iron and battery and charger units from a new source — Gulton Industries Alkaline Battery Division.

Write today for complete technical information — please mention your application.

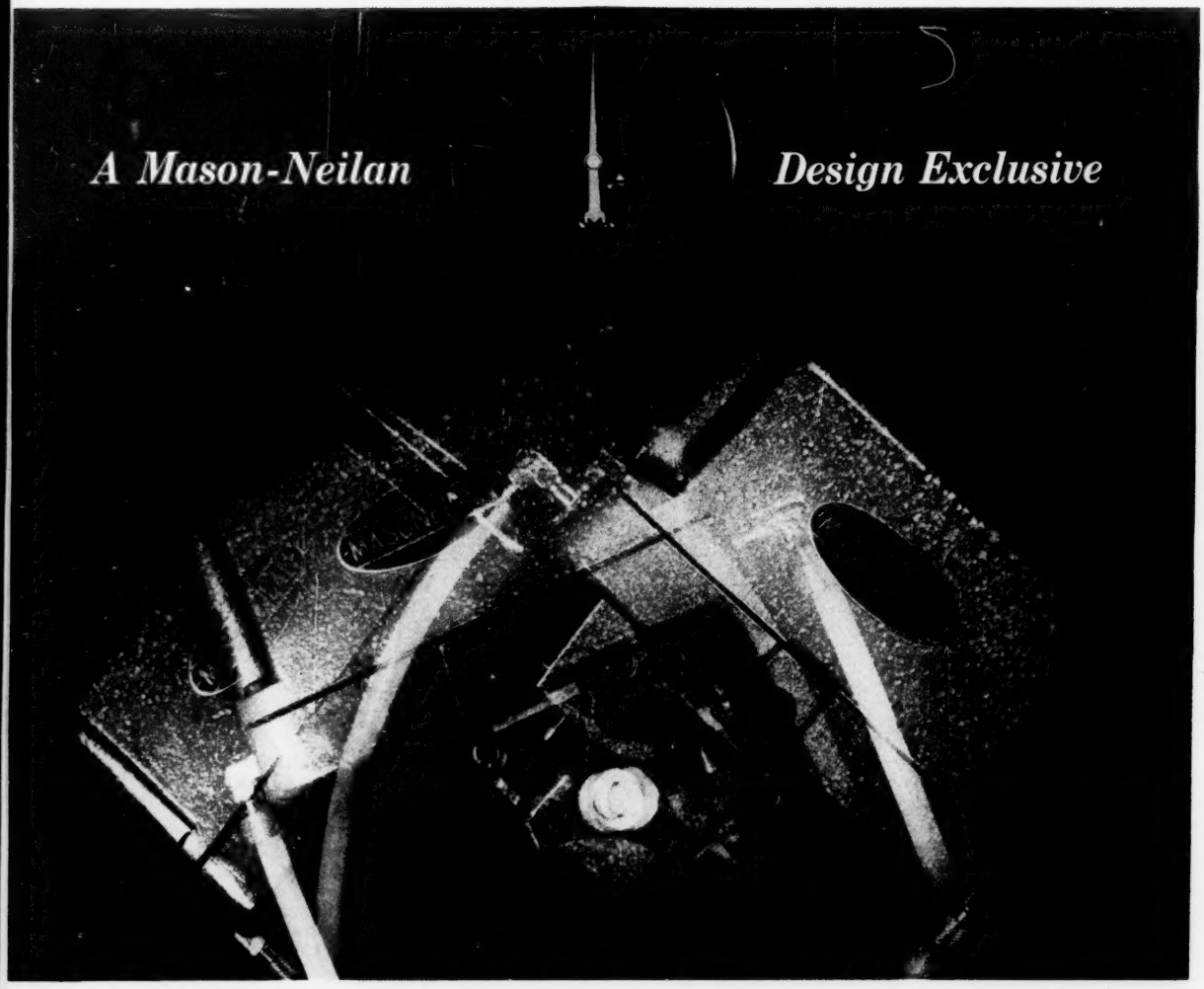
Gulton
ALKALINE BATTERIES

Alkaline Battery Division

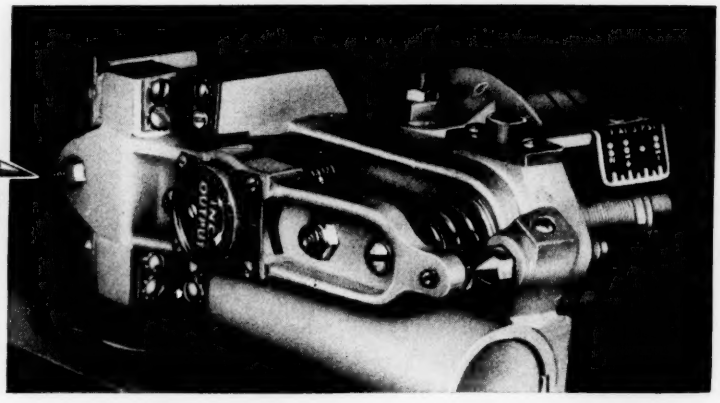
Gulton Industries, Inc.

METUCHEN, NEW JERSEY

For more information circle **38** on inquiry card.



This oscillating test mount demonstrates the effectiveness of Masoneilan "Balanced Beam" design. Output pressure does not change, regardless of transmitter position.



Balanced beam construction also shows how the entire assembly has been compactly designed. Adjustment on front of beam provides means of synchronizing output range with the primary element span. Damage protection is provided for primary element, by beam stop and overrange feature; for compensating bellows by built-in stops; for entire unit by rugged, weather-proof case.

For more information circle **39** on inquiry card.

Masoneilan Pressure and Temperature Transmitters use Balanced Beam to Prevent Zero Shift

The new Masoneilan Transmitters feature a distinctive balanced beam design which eliminates positional error

In addition, these transmitters offer several other important design advances. Unit construction simplifies change or removal of subassemblies; All adjustments are visible and accessible; Large pilot capacity insures fast operation with long transmission lines; and Unit is compensated for ambient temperature and barometric pressure.

Write for Bulletin

Complete information and data on this new instrument is now available. Write for your copy or ask for details at your nearest Mason-Neilan office.

MASON-NEILAN

Division of Worthington Corporation

55 NAHATAN STREET, NORWOOD, MASS.

SEVENTY-FIFTH 75 ANNIVERSARY 1881 1956

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Houston • Atlanta • Cleveland • Cincinnati • Kansas City • Phoenix
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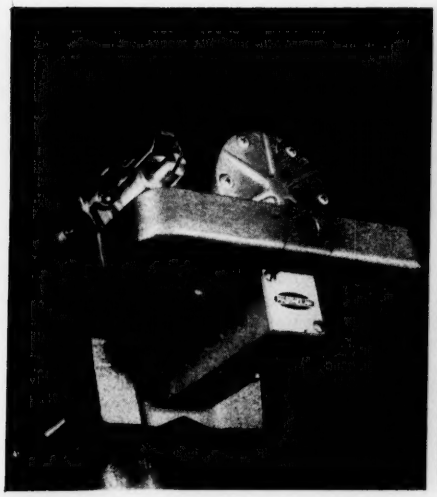
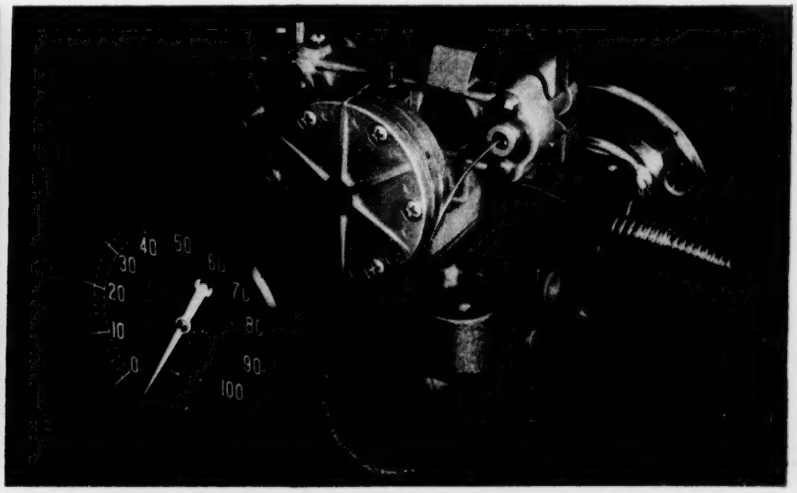
Appleton • Birmingham • New Orleans • Seattle • Jacksonville
Wilmington • Mason-Neilan Regulator Co., Ltd., Montreal & Toronto



The derivative unit compensates for lags in the thermal system. It can be quickly added on the underside of base plate, and requires no tubing or fittings. Mounting block attaches to flat surface or forms clamp for pipe.



Unit Subassembly construction permits simplified removal or change of primary element; compensating bellows; feed-back bellows; pilot; range span adjustment; derivative unit; and gasketless nozzle — any or all without disturbing beam assembly in any way. Integral Receiver Gage is another Masoneilan feature — can be mounted directly on base plate without external connections.

For more information circle **39** on inquiry card.

SHOWS CO Hazard INSTANTLY

- Shows CO hazard directly — at a glance
- Requires no color matching or reference to comparator scales
- Test takes only a few seconds
- Simple in operation; easy to use
- No special training needed

MONOXOR CARBON MONOXIDE DETECTOR

REPLACEABLE DETECTOR TUBE CONTAINS YELLOW CHEMICAL WHICH TURNS BROWN WHEN AIR "SNIFFED" THROUGH DETECTOR TUBE BY PENCIL-SIZE ASPIRATOR CONTAINS CARBON MONOXIDE

The MONOXOR detects presence of CO, even in concentrations as low as 100 parts CO per million parts of air. Particularly useful for a spot-check of carbon monoxide contamination in garages, vehicular tunnels, mines, industrial plants and wherever gas appliances are operated.

$22.70 Price Complete—includes MONOXOR Instrument, 24 Detector Tubes, 6 Tube Caps, in Pocket Case

For Complete Particulars . . . Clip this ad and mail to us with your name and address, or write for Leaflet 859.

BACHARACH INDUSTRIAL INSTRUMENT CO.
200 N. BRADDOCK AVE. • PITTSBURGH 8, PA.
Telephone: CHurchill 2-5400 M-9r

For more information circle **40** on inquiry card.

Wilmad

ELECTRONIC ENGINEERS!

FOR ECONOMY AND EFFICIENCY DESIGN WITH PRECISION GLASSWARE!

To keep costs down and yet get the maximum efficiency in electronic parts and sub-assemblies, more design engineers are turning to glassware.

The reason is simple: the amazing tolerance limits, the low cost, and the unbelievable accuracy and uniformity of Wilmad precision glassware have made many metals, plastics and ceramics far too expensive.

If you design electric or electronic devices of any kind such as wave guide tubes, UHF tuners and cavities, voltage regulators, capacitors, dashpots, etc., investigate the economy and efficiency of precision glassware. Our engineers welcome the opportunity of discussing any of your design problems with you. Send for our new bulletin today.

Wilmad
GLASS COMPANY, INC.
LANDISVILLE, N. J.

For more information circle **41** on inquiry card.

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Radioactivity Instruments

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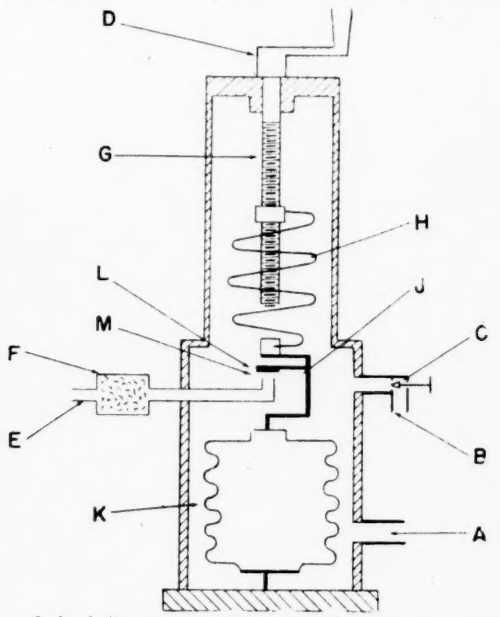
(From new 132-page 1958 Catalog, including radiation detectors and accessories, Radiation Counter Laboratories, 5121 W. Grove St., Skokie, Ill.)

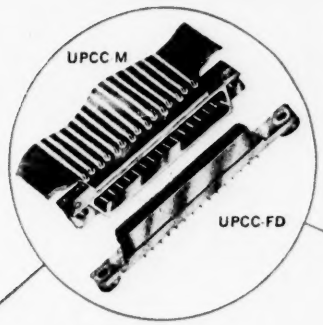
For this literature circle **212** on inquiry card.

Aneroid Manostat

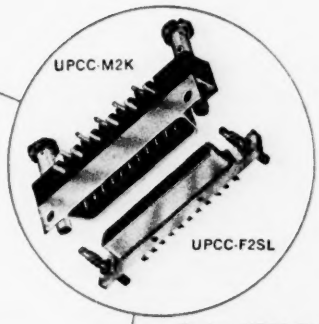
A vacuum system to be controlled by the Manostat is connected to "A" and the source of vacuum to "B". Vacuum throttling valve "C" is opened and adjusted to suit the capacity of the vacuum pump . . . Expansion or contraction of the bellows moves the valve disc away or toward the port, respectively, and thereby controls the flow of air through the Manostat. For example, to maintain a vacuum test chamber at 15 inches of mercury absolute pressure, the Manostat handwheel is adjusted until the desired pressure is indicated on a manometer or other indicator connected into the system. The net resultant force of the bellows and the spring allows just sufficient air to pass through the port to maintain equilibrium. If the pumping rate of the source of vacuum or atmospheric pressure changes, the bellows immediately reacts and throttles the air inlet so the equilibrium is maintained . . . . *(From new General Catalog binder containing ten 4-page pamphlets, Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J.)*



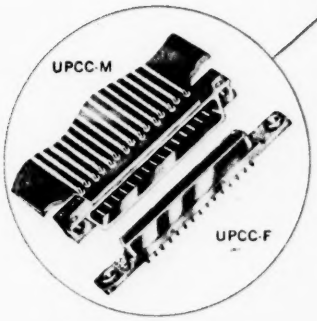
For this literature circle **213** on inquiry card.



Series UPCC-FD
Female chassis connector-dip solder terminals.

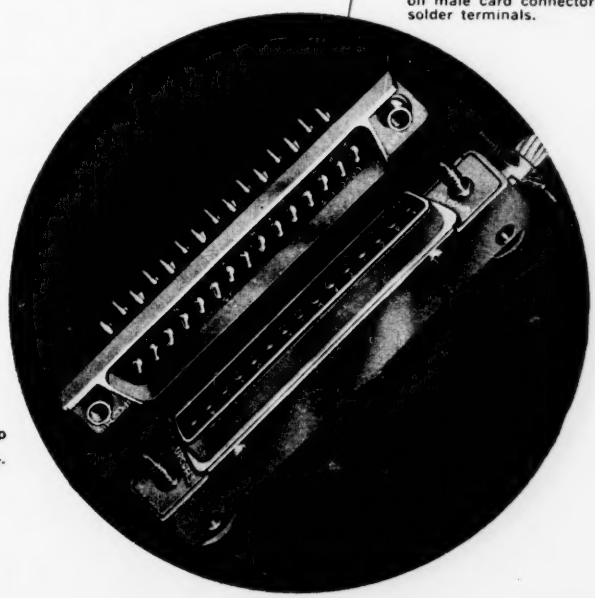


Series UPCC-SLK*
(Knob Screw-Lock).
Female chassis connector-wire solder terminals. Knob on male card connector-dip solder terminals.



Series UPCC-M & -F
NAS standard.
Male card connector-dip solder terminals.
Female chassis unit with wire-solder terminals.

and now...



Series UPCC-SLH*
Male chassis connector-dip solder terminals.
Female hooded connector-wire solder terminals.

another "demand" member has joined U.S.C.

family of Printed Card Connectors . . . the new, hooded screw lock Series UPCC . . . SLH bringing the total of different available types to over 150.

- Conforms to MIL-C-8384 and NAS specs.
- Molding materials—melamine and diallyl phthalate
- Die cast aluminum shells—aluminum hoods
- Ideal for critical environmental conditions
- Silver plated—gold flash contacts
- Screw lock elements—stainless steel—double lead for double speed

All UPCC-M & -F units available with wire-solder; turret type; or solder dip terminals (for 1/16, 1/8, 1/4" boards).

Max. Wire Size	#18 AWG
Voltage Breakdown (Min.)	1800v, AC, RMS
Insulation Resistance	over 5000 megohms
No. of contacts	7, 11, 15, 19, 23
Current Ratings	7.5 amps

Also custom configurations to meet your specific application requirements.

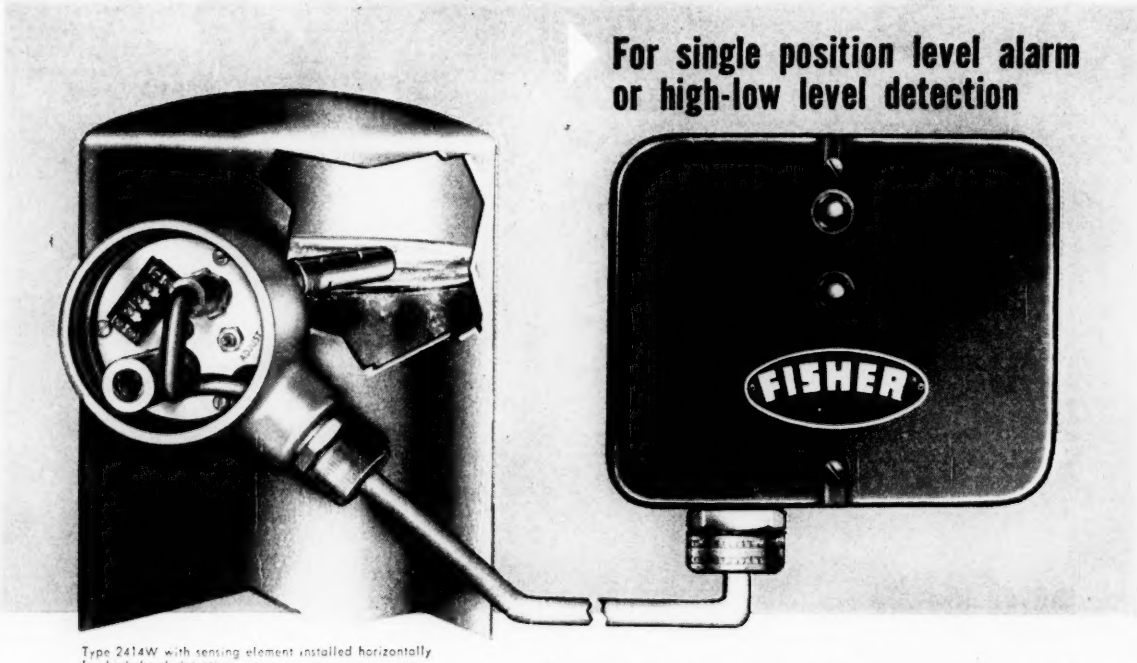
*Pat Pend.

U.S. COMPONENTS, INC. associated with U. S. Tool & Mfg. Co., Inc.
454 East 148th Street • New York 55, N. Y. • CYpress 2-6525

For more information circle **42** on inquiry card.

The Capaci-trol—a capacitance type level position detector

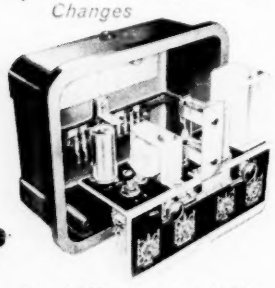
For single position level alarm or high-low level detection



Type 2414W with sensing element installed horizontally for high level detection.

- *Compact Construction*
- *No Moving Parts*
- *Pressures up to 2500 psi*
- *Requires only 110 a. c. to operate*
- *Unaffected by Supply Voltage Variations*
- *Temperature Application Range From −50° F. to +150° F.*
- *Unaffected by Ambient Temperature Changes*

The Capaci-Trol is an electronic-electric level alarm and control unit for detection of level position in vessels—either as single point level detection for high or low level alarm applications or for high-low differential gap level detections. Units operate with power frequencies of 60 cycles utilizing a capacitance bridge circuit in conjunction with a rugged and durable Thyratron tube. Requiring only 110 a. c. supply voltage, the Capaci-Trol is completely self-contained and has no moving parts. The electrical output can be used to operate solenoid valves, motor starters, indicator lights, alarms, etc. All components of the Capaci-Trol are of the highest quality available, insuring maximum dependability and long life.



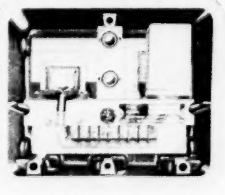
Type 2408W control unit featuring plug-in chassis.

AVAILABLE IN TWO MODELS

TYPE 2408W DIFFERENTIAL GAP CONTROLLER. The Type 2408W can be used in a wide range of conducting liquids for two-position control of level. Components are mounted on a plug-in chassis housed in a weather-proof aluminum case. Sensing elements available in lengths from 6" to 36" which is connected to remote control unit with coaxial cable. Maximum differential gap—80% of total length of sensing element. Minimum differential gap—0.5".

TYPE 2414W HIGH OR LOW LEVEL ALARM. The Type 2414W High or Low Level Alarm unit, as shown above, is designed for use in both conducting and non-conducting liquids. This, in general, includes the range from aqueous solutions to petroleum oils. Weather-proof housings are used for all components. Thyratron tube is in head portion of sensing element, thus requiring only standard wire in connecting to control case.

Write for Bulletin F-2408 for complete information



Type 2414W remote case contains power supply, relay and lights. Thyratron tube and level adjustment located in conduiet on top of sensing element.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

FISHER®

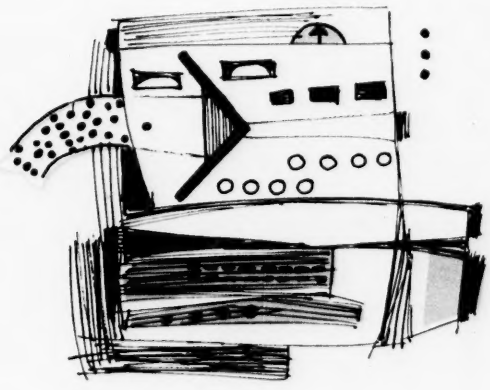
For more information circle **43** on inquiry card.

EVEN IF YOU disAGREE . . .

with many of the opinions herein, you've likely found lots to interest you in this special January "Systems" issue of Instruments & Automation.

It's but one of a series of issues commemorating 30 years service to industry, each devoted to special and sometimes controversial control topics.

Several other great special issues are in preparation . . . for example . . . next month we focus attention on "Automation in the Iron and Steel Industry."

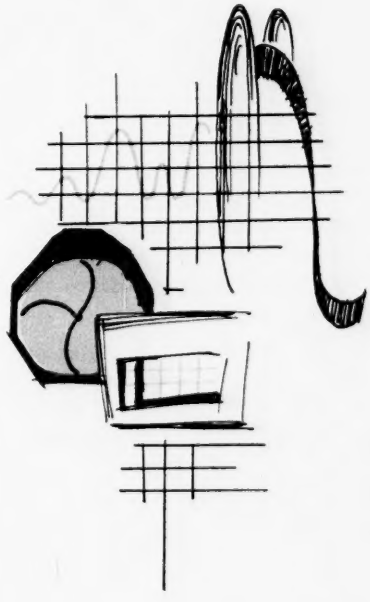


February Instruments & Automation will cover particular details in this specific field of control application with articles on:

Blast-Furnace Instrumentation
Open Hearth Instrumentation
Sintering Plant Instrumentation
Stove Changing Instrumentation
Galvanizing-Line Instrumentation
Electrolytic Tin Line Instrumentation
Vacuum Melting Instrumentation
Oxygen Plant Instrumentation
Edge Position Control
ITV in Iron & Steel Industry
Valves for Iron & Steel Industry

Another special issue now being prepared for you is the May, 1958 issue—which will survey the entire field of **recording apparatus and techniques**—chart and tape. Included will be articles covering

Oscillographic recorders
Digital data recorders for dense storage
Automatic null-balancing recorders
Magnetic tape recorders, analog and digital
Photoelectric recorders
Special medical recorders
Multi-segmental recorders
Sweep-balance recorders
Heat-Sensitive recorders
Wax paper recorders
Kymograph recorders



This special "recorder" issue of Instruments & Automation also will preview the Fourth International Automation Exposition and Congress, June 9-13, New York Coliseum.

AS A READER, you stand to gain heavily from all of I&A's special anniversary issues. Advertisers, too, find these to be exceptionally well-read issues, full of extra promotional values.

To renew your subscription, or subscribe for an associate, use the card on page 193. For advertising details contact any of our offices—listed on page 3.

INSTRUMENTS and AUTOMATION **845 Ridge Ave., Pittsburgh 12, Pa.**

Write for this Bulletin on . . .

CRESCENT ARMORED MULTITUBE

BETTER PROTECTED TUBING

LOWEST INSTALLED COST

SAVE MONEY, TIME, SPACE

Get a better and completely protected installation for permanence.

Find out NOW the advantages and economy of this advanced method of installing cabled INSTRUMENTATION and CONTROL TUBING

This interesting Bulletin gives you complete technical information on various types of Cabled Tubes for instrument controls, as well as methods of installation.

CRESCENT ARMORED MULTITUBE* is a group of copper, aluminum or polyethylene tubes *spirally cabled* together, which prevents distortion of the tubes when bent on a short radius. The tubes are protected by a flexible steel armor, and where desired by corrosion-resistant sheaths.

This Bulletin illustrates all types of CRESCENT MULTITUBE, describing their advantages in detail. It also shows the accessories needed for connecting the junction boxes or panels, and for mounting and supporting the tube.

Licensed under U. S. Patent 2,578,280.

*Reg. Trade Mark

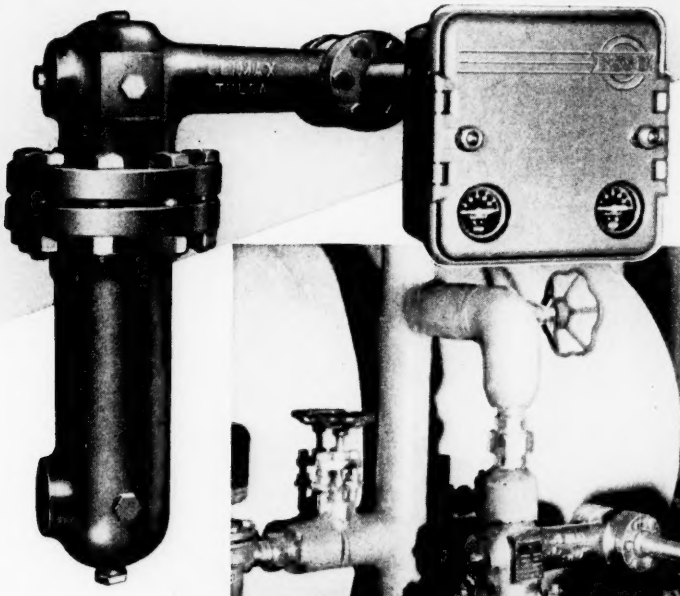
Write for BULLETIN NO. 356-A

CRESCENT INSULATED WIRE & CABLE CO.

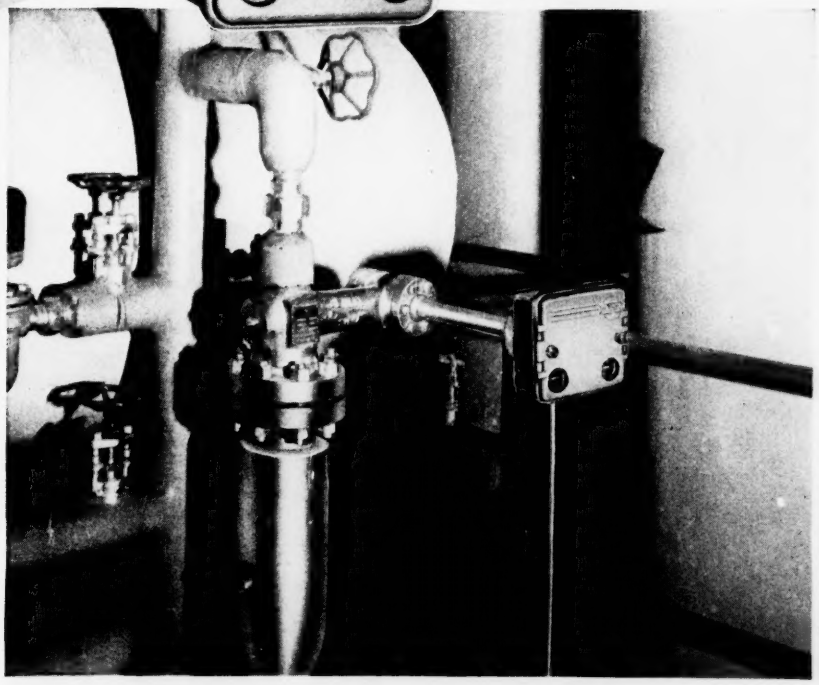
TRENTON, NEW JERSEY

For more information circle **44** on inquiry card.

When An External Cage Type Liquid Level Controller Is Indicated, Specify The . . .



BS&B Type 71-06, Series 2!



OVER 60 YEARS
BS&B
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

1. **"Built In" Accuracy:** Engineered to control within close level tolerances.
2. **Rugged:** Capable of continuous operation under severe service conditions.
3. **Versatile:** May be either transmitter or controller. Set for differential-gap, on-off, or proportional control. Controller output range in 3-15, 3-27 and 6-30 psig.
4. **Time Proven:** Utilized on heat exchangers, reboilers, deaerators, condenser hotwells and other similar applications in plants the world over.

For Complete Information On The BS&B Type 71-06, Series 2, Or Other BS&B Liquid Level Controllers, Contact Your BS&B Sales Engineer — or Write To . . .

BLACK, SIVALLS & BRYSON, INC.
Controls Division, Dept. 4-VI
7500 East 12th Street
Kansas City 26, Missouri

For more information circle **45** on inquiry card.

What's your tubing problem?

corrosion?
damage?
installation?
fire? cost?

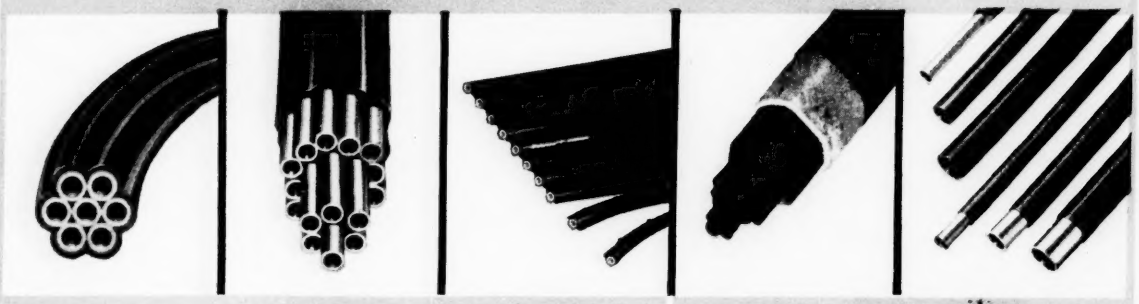
Wherever instrument tubing is used—be it refinery, natural gasoline plant, chemical, nuclear or food processing—Dekoron Tubing Products can help whip your ultimate twin problems of *maintenance-replacement expense and installation costs.*

Why?

First, because Dekoron Tubing products resist chemical attack and corrosion caused by moisture and industrial atmospheres. That means that once installed, Dekoron products are in to stay. You're not faced by perennial replacement and maintenance costs.

Second, the big savings in cost are yours in installation when you specify multiple-line Dekoron products—you install many instrument lines at once.

So if you have an instrument tubing problem of *any sort*, we probably have the answer *in stock*. If not, we can design and make it for you.



POLY-COR
From 2 up to 37 plastic tubes in plastic armor.

METL-COR
From 2 up to 19 copper or aluminum tubes in plastic armor.

RIBBON
M-Ribbon (metal) and P-Ribbon (plastic). 10 tubes in plastic sheath.

PROTECTO-PAC
Fire and impact resistant. Plastic tubes covered with plastic-asbestos-plastic armor.

SINGLE-LINE
Single steel, copper or aluminum tubes in plastic armor, or all-plastic tubing.

Dekoron® products
QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & CO.
Dekoron Products Division
MANTUA, OHIO

AA-6068

For more information circle **46** on inquiry card.

BIOGRAPHIES
of Significance

IT IS not generally known that the Civil Service of the United States of America has been weakened by the many attacks that have been made on it.

It gives us great pleasure this month to acknowledge, with deep gratitude, the contributions to our nation and our industry that have been made by a dedicated civil servant, a man whose work both before and after "retirement" deserves the accolades of our field. This month our biography pays tribute not only to "Brom" Brombacher, but to the Civil Service of the United States of America.

William G. Brombacher

William G. Brombacher

Dr. William G. Brombacher was Chief of the Mechanical Instruments Section of the National Bureau of Standards for 35 years—before he "retired" in 1954. For most of these 35 years he was one of the country's leading authorities on mechanical instruments, particularly pressure instruments, humidity instruments, aeronautical instruments and airborne oxygen equipment.

Born in Cleveland, Ohio, in 1891, he attended Lake Forrest college for undergraduate and graduate work, receiving his M. A. in physics in 1917. He continued his studies at John Hopkins University in 1919 and received his Ph.D in 1922, at which time he joined the staff of the National Bureau of Standards.

He has been a section chief at NBS since 1926, at which time he was appointed Chief of the Aeronautic Instruments Section, the predecessor of the present section.

"Brom," as he is affectionately called by his many friends, has made many contributions to the Bureau's research program in mechanical instruments. His main problems have centered around the problem of refining and developing more accurate standards of pressure and humidity and related physical quantities. Under Dr. Brombacher's guidance the range of precise pressure measurement was extended upward to 200,000 psi and downward to 0.00001 psi.

Not a year has passed since 1922 without one or more basic reports by Brombacher on aircraft instrumentation appearing in the literature of our field. A simple listing of these would fill columns. World War II saw Brom in England, where he obtained data on English developments for the U. S. Navy.

A measure of Brom's contributions can be had simply by listing his activities since retirement:

He has served continuously as a consultant to the Mechanics Division of the Bureau, where he has a desk. In addition to several NBS reports, he has performed surveys on the measurement of free air temperature, air-speed measurement, etc.

In 1955 he co-authored two fundamental books of our field—*Bibliography and Index on Dynamic Pressure Measurement by* W. G. Brombacher and T. W. Lashof (Circular 558, NBS, available from GPO, 124 pages, 75 cents), and *Guide to Instrumentation Literature* by W. G. Brombacher, J. F. Smith and L. M. Van der Pyl (NBS Circular 567, available from GPO, 156 pages, $1.00).

From September to December of 1957 he served as consultant to the Turkish Standards Institution in Turkey, a project made possible by the cooperation of the International Cooperation Administration (ICA). There he assisted with a program for standardizing commercial and agricultural products, using the facilities of several independent laboratories in Turkey.

Many of the innumerable articles which Dr. Brombacher wrote were published in *Instruments* magazine, the predecessor of *Instruments and Automation*. The chapter on Aviation Instruments in the *Handbook of Measurement and Control* edited by M. F. Behar is another of his contributions. Brom tells us that he has been a reader of *I&A* since 1928—a full 30 years.

Among the many societies of which Dr. Brombacher is a member are the American Institute of Physics, the Federation of American Scientists, the Philosophical Society of Washington, the Instrument Society of America, and the American Society of Mechanical Engineers. Brom is especially proud of being a Fellow of the Institute of Aeronautical Sciences and an Honorary Member of the Instrument Society of America.

The reliability of Statham transducers is demonstrated by an experience reported by Chance Vought:

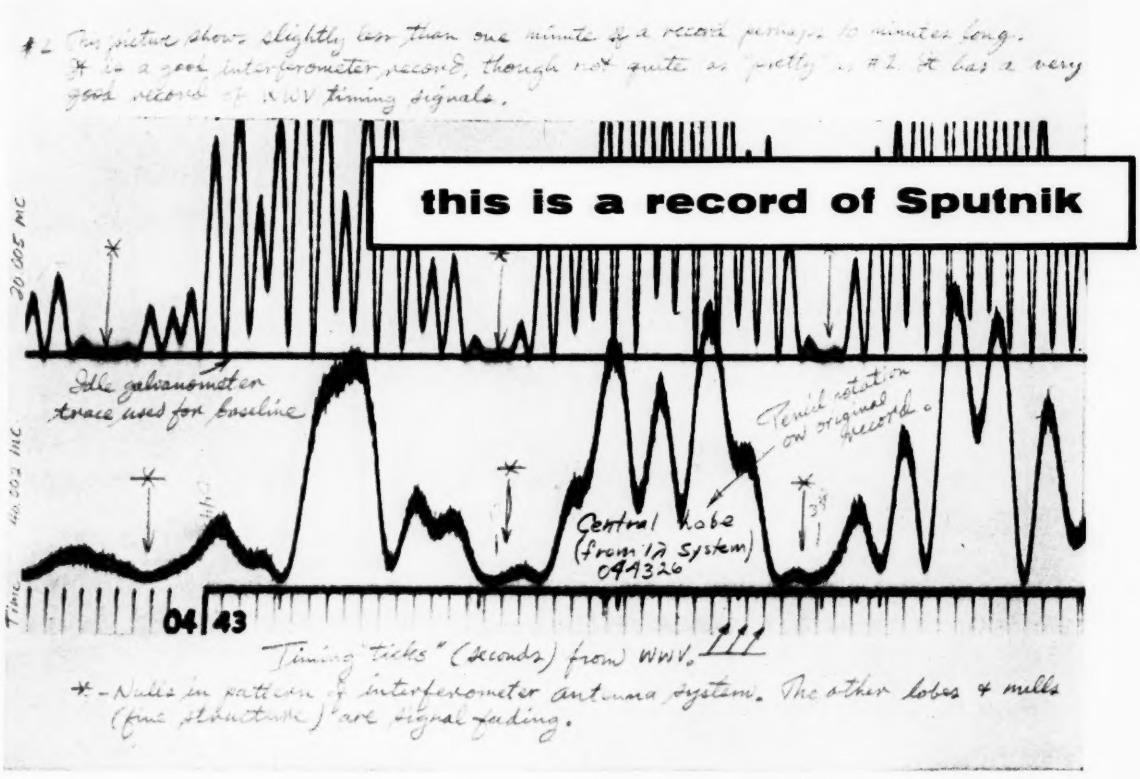
Two Statham pressure transducers which had not been calibrated for six years were recently calibrated with a resulting curve that checked within 2% of the last calibration.

IF YOU NEED
Linear Accelerometers
Angular Accelerometers
Gage Pressure Transducers
Absolute Pressure Transducers
Differential Pressure Transducers
in your instrumentation programs, please outline your requirements so we may submit specific recommendations.

WHEN THE NEED IS TO KNOW... FOR SURE SPECIFY STATHAM

Statham
INSTRUMENTS, INC.
LOS ANGELES 64

For more information circle 47 on inquiry card.

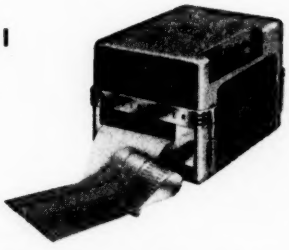

#2 This picture shows slightly less than one minute of a record perhaps 10 minutes long. It is a good interferometer record, though not quite as "pretty" as #2. It has a very good record of WWV timing signals.
this is a record of Sputnik
20.005 MC
Idle galvanometer trace used for baseline
Pencil rotation on original record.
Central lobe (from 1/2 system) 094326
04 43
Timing "ticks" (seconds) from WWV.
*-Nulls in pattern of interferometer antenna system. The other lobes & nulls (fine structure) are signal fading.

The Visicorder has charted the orbit of Sputnik I

A Model 906 Honeywell Visicorder Oscillograph wrote this record of the signals from Sputnik I for the Department of Electrical Engineering at the University of Illinois at Urbana. The marginal notes are those of Edgar Hayden, the research associate who took the record.

Interferometer-type antenna systems (2 dipole elements ⅛ wavelength above ground spaced several wavelengths along a north-south baseline) received the two signals for communications-type radio receivers. The beat oscillators generated audio output signals, a semi-conductor bridge circuit rectified them, and the d-c output, filtered by an R-C network with a time constant of about .003 seconds, was used to drive the Visicorder galvanometers directly.

The Visicorder, teamed with the interferometer antenna, quickly established a record of the orbit of Sputnik I.



The Honeywell Visicorder is the first high-frequency, high-sensitivity *direct* recording oscillograph. In laboratories and in the field everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis Honeywell Industrial Sales Office for a demonstration.

Honeywell

Heiland Division

Minneapolis Honeywell Regulator Co., Heiland Division, 5200 E. Evans Ave., Denver 22, Colo. **Reference Data: Write for Visicorder Bulletin**

For more information circle **48** on inquiry card.

NEW! pneumatic transmitting tachometer with

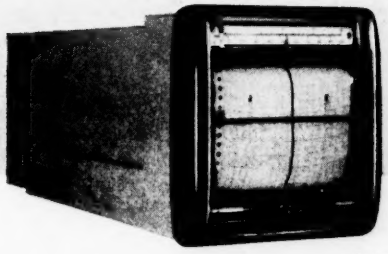
DIRECT LINEAR SIGNAL

the Foxboro Type 16A Pneumatic Speed Transmitter

- **mounts in any position**
- **accurate to ±½% across entire range**
- **adjustable span and zero**
- **Dust-tight gasketed case continuously purged**
- **Low cost compared with other recording tachometers**
- **Operates on simple force-balance mechanical principle.**

Direct-connects to remote pneumatic recorder or controller, such as Consotrol* panel recorder shown below.

***Reg. U.S. Pat. Off.**



At last — a tachometer with 3-15 psi air signal *directly proportional* to rpm! Speed changes are recorded on a uniform-scale chart. Accurate measurements of rpm are easy to read throughout the entire range. No crowded bottom scale!

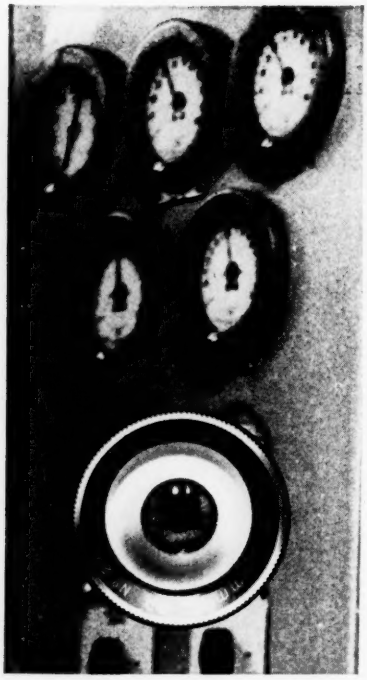
The Type 16A Speed Transmitter is available for ranges from 0-320 rpm to 0-5300 rpm. Full-scale accuracy of ±½% is consistently maintained. Small and light weight, it can be mounted *in any position* — never needs lubrication.

For rotating equipment having wide speed variations, the Type 16A is ideal. It can easily be incorporated into any present pneumatic control system. Write for full details.
The Foxboro Company, 461 Neponset Avenue, Foxboro, Massachusetts, U.S.A.

FOXBORO
REG. U.S. PAT. OFF.

PNEUMATIC SPEED TRANSMITTERS

For more information circle **49** on industry card.



casting a miserly eye

at power meters to control peak loads is one cost-cutting job of GPL closed-circuit television.

How many jobs could GPL Industrial TV help you do better?

You'll never know until you investigate! You'll be amazed at the versatility, simple operation, and low cost of Industrial TV systems by GPL, one of the world's leading manufacturers of industrial, military and broadcast TV.

Write us today for free, illustrated brochure on GPL—the most complete line in the industry.

GPL

GENERAL PRECISION LABORATORY INC.
PLEASANTVILLE, NEW YORK

For more information circle **50** on inquiry card.

Panhandle Pete

The Instrument Salesman

Monday. January 6. Up bright and early, still full of Xmas cheer and high resolutions. Looked over possible calls down West Virginia way to pick out six likely suck . . er, customers, and replenish my stock of West Virginia whiskey.

Pulled up garage door; car seemed to be sitting whopper-jawed—front tire flat.

11:00 AM. Tire finally fixed, time for lunch. Pick out best two clients and on my way.

1:00 PM. This West Virginia Electronic, Coke and Petroleum Company is a hard place to find. Receptionist says to wait in waiting room. Eight guys there—I recognize seven as instrument salesmen; wonder who eighth is?

1:15. Salesman 1 goes into office.

3:10. Salesman 6 enters—much loud laughter. Wonder if they are telling "my story"? These trade journals in the waiting room sure come in handy.

4:00. My turn! Hooray! With only one call to-day, I better score!

In inner office see sign: PEDDLERS . . . turn left. SYSTEMS ENGINEERS . . . turn right. Space Salesmen . . . basement. What am I selling? Turn left into another waiting room. After fifteen minutes young executive type comes out and introduces himself as Twenty Third Assistant Procurement Helper.

Explain our complete line of automation equipment—gas analyzers, computers, air filters, Par-Kometers, etc. . . Ask to see Chief Engineer or Instrument Department Head. Everybody busy. Left a stack of catalogs for the men; looks like no-sale today. Asked where Systems Engineers went when they turned right in waiting room? "Into office of Vice-President, Production," says junior (executive). Left another stack of catalogs with young pun . . er, executive and sneaked up-stairs into the office of the Vice-President; that's why I'm the most dynamic salesman of instruments in our organization!

Walked in and introduced myself. Vice-President tickled pink to talk to a real honest-to-gawd System Engineer. Thought they were only found in the technical literature. Wanted to know what kind of system I could engineer. Silly boy!—any kind, of course. We have a computer and a gas analyzer; these are the essentials. The rest can be system engineered. Saw I was on right track. V.P. tells me phenol recovery plant is getting old; needs new system. Can we do it? What a naive question! Made immediate appointment with Chief Engineer and Chairman of Board. Holy Smokes!

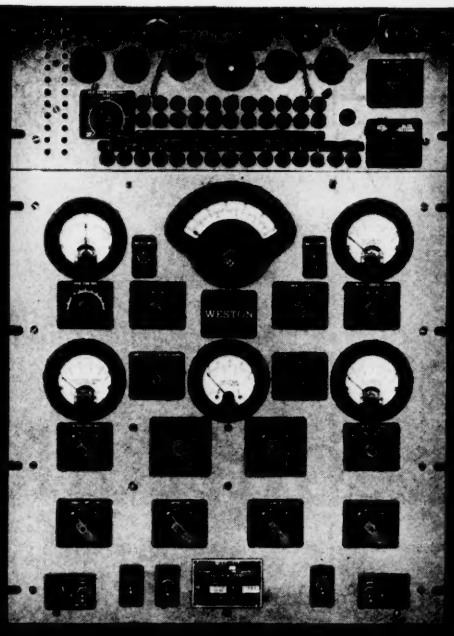
Chief engineer liked simplicity and price of our O. J. Computer. Bought two for use in planimetering steam charts and figuring over-time. Combustion Engineer got the bird when he looked at our Aves analyzer. Bought one analyzer with two spare cells for use in tar plant where Orsat-type keeps plugging up. Bought another O. J. for calculating orifice constants. Signs order for $975.25.

Saw the Chairman of the Board *and* the Comptroller. They really roll out the red carpet for us System Engineers! After pouring me a drink and stuffing my pockets with good cigars the first question asked is "Why do we need a computer?" Almost slipped and said so I can make more money, but the modern trade journals sure come in handy. I just tell them what I read while spending the afternoon in the waiting room: "Plant managers need more information and need it faster to keep up with trends; market is changing; you don't want to be the last company without one; etc." Talk two hours about data processing, data logging, centralized control systems and subsystems, show them block diagrams with weather and market information going into one end of their plant and coke and phenol coming out the other. Clinch sale when I mentions that plant is three miles long and needs fast electronic control.

Have rough time with questions about cost of control system, but duck all these by pointing out we select optimally the optimum system which closes the optimum loop between the optimum Aves analyzer and the optimum O. J. Computer. Also tell them we will re-design the computer so that it can be used for accounting and telling fortunes . . . er, anticipating trends . . . when engineering is not planimetering charts. Sign order for $946,374.43 and guarantee one operating closed-loop around entire plant, complete with computer and instruction book—but no delivery date.

Only one report to fill out after I got home and put away another case of West Virginia Whiskey, a gift from the Vice-President. "Sold three O. J.'s and one Aves Analyzer with spares . . . and one closed loop." Factory never made any of these before. Wonder what old Klapsaddle will say? I'm no instrument peddler no more—I sell systems now!

Panhandle Pete



LABORATORY MODEL (686)

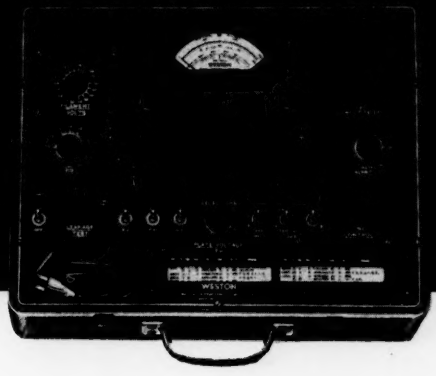
- A true mutual conductance analyzer that tests tubes under actual circuit operating potentials. Overall GM accuracy is 3% or better.
- Transconductance is measured directly without need for null adjustments or corrections, providing GM readings on all receiving type tubes.
- Circuit is mathematically calibrated and requires no calibrated tubes for GM circuit standardization.

A real laboratory for electron tubes. Model 686 is entirely self-contained, with a filtered d.c. power source, special circuitry to keep meter loading effects negligible, and a well regulated grid bias supply.

by **WESTON**

PORTABLE MODEL (981)

- Filtered d.c. potentials provide better GM accuracy.
- Voltage divider network for better grid bias settings.
- Four signal levels provided protect against excessive grid current surges.
- Provision for tube interelectrode leakage measurements as high as 10 megohms.

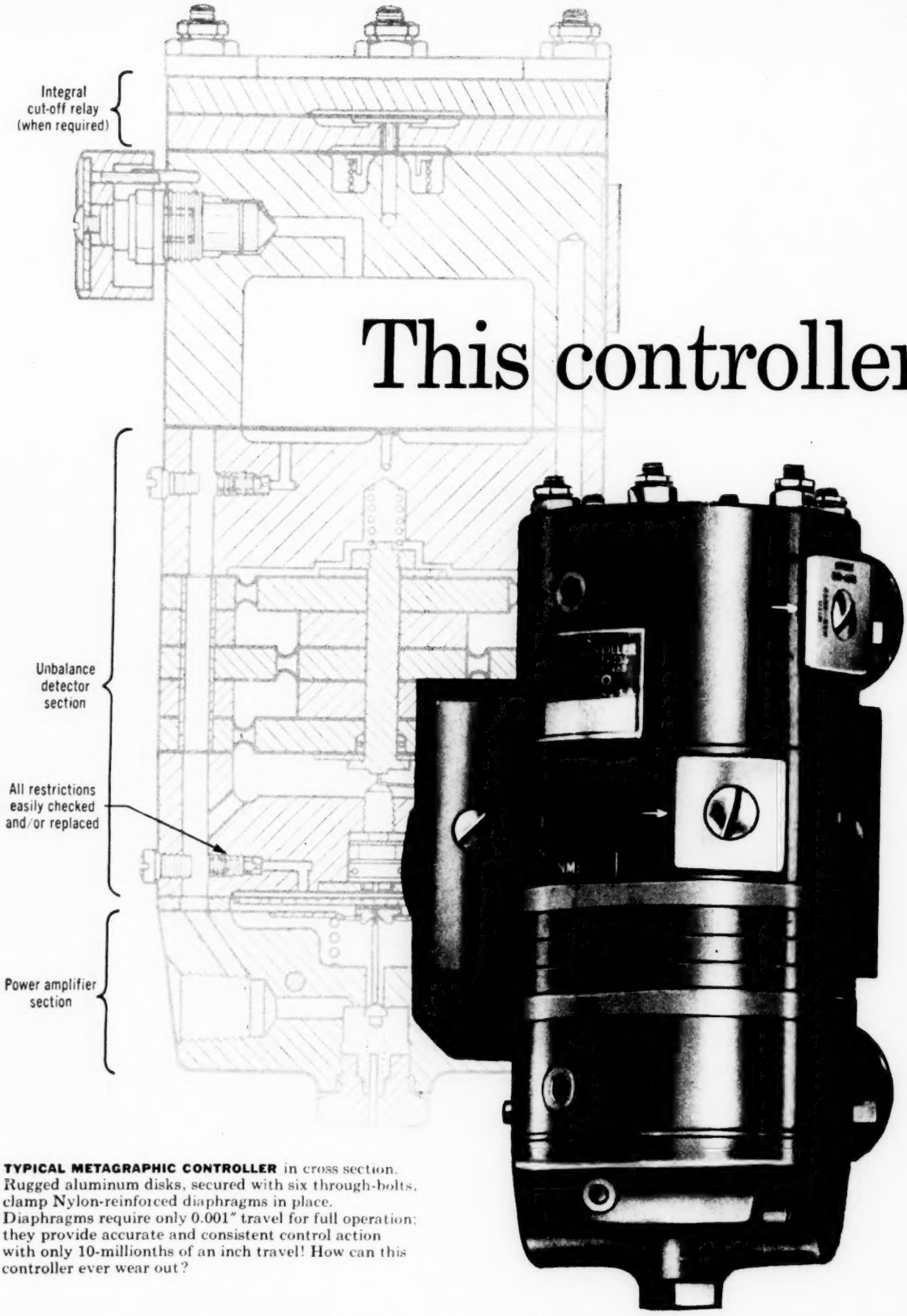


Whether for production quality control . . . laboratory analysis of tube characteristics . . . or quick accurate servicing of electronic equipment, WESTON tubecheckers are acknowledged leaders for accuracy, time-saving facility, and long term dependability. These and other Weston test instruments are available through leading distributors. Bulletin available by writing WESTON INSTRUMENTS, Division of DAYSTROM, INC., 614 Frelinghuysen Avenue, Newark 12, New Jersey.

WESTON
TEST EQUIPMENT

A DAYSTROM UNIT

For more information circle **51** on inquiry card.


Integral cut-off relay (when required)
Unbalance detector section
All restrictions easily checked and/or replaced
Power amplifier section

This controller

TYPICAL METAGRAPHIC CONTROLLER in cross section. Rugged aluminum disks, secured with six through-bolts, clamp Nylon-reinforced diaphragms in place. Diaphragms require only 0.001" travel for full operation; they provide accurate and consistent control action with only 10-millionths of an inch travel! How can this controller ever wear out?

For more information circle 52 on reply card.

FIVE MODES OF CONTROL

1 Fixed High-Gain (on-off)
2 Adjustable Gain Proportional
3 Proportional-plus-Reset
4 Fixed-Proportional plus Fast-Reset
5 Proportional-plus-Reset-plus-Derivative

Heat . . . rain . . . snow . . . ice . . .
overpressures . . . years of use . . .

stays on the job!

Operates from "universal" 3-15 psi pneumatic input signal . . . supplies precision pneumatic control of almost any variable

If your process needs a tough boss, here it is.

The Bristol Metagraphic Pneumatic Controller can take all the abuse either environment or process can hand out and still keep right on working. Its bolted, stack-type construction gives it practically the same durability as a solid metal cylinder. Its proved force-balance operating mechanism provides the most sensitive control in process handling, yet withstands overpressures of 100 psi on any connection. And check these features:

36 models to choose from.

Full plug-in service, where desired – With no loss of air pressure or disturbance to the indicating-recording action.

No bearings, no links, no levers – Operation is virtually motionless and frictionless.

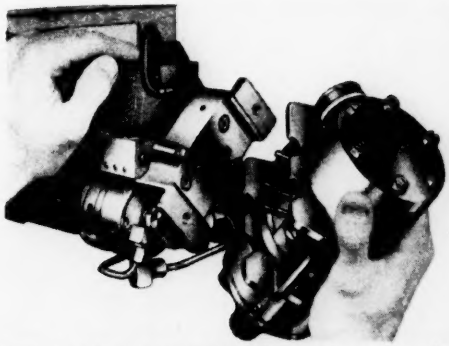
High sensitivity – Only 0.01% change in input pressure produces measurable output change.

Wide ambient temperature limits – From −65° F to +225° F.

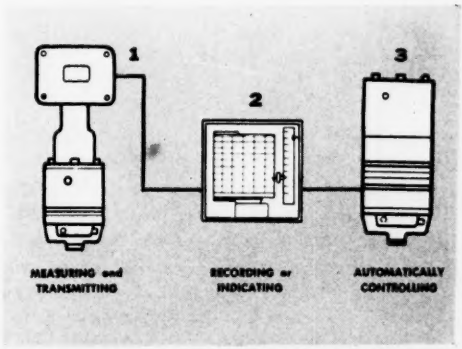
High output capacity – Up to 3 scfm on pipe connected models.

Low air consumption – Only 0.2 scfm when balanced.

Write for complete data on the Bristol Metagraphic Pneumatic Controller today. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 7 50



FULL PLUG-IN FLEXIBILITY for receiver mounting or field mounting allows one-minute controller substitution with no disturbance to recording or indication.



HOW BRISTOL METAGRAPHIC CONTROLLER (3) fits into complete system. Controller may be located directly at controlled process or conveniently plugged into receiver (2).

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **52** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
INLET PORT
DISCHARGE PORT
DISCHARGE PORT
INLET PORT
ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

Circle **53** on inquiry card. ⟶

are you fighting space?

Are you looking for complete electrical circuit dependability in a very, very small space?

If so, you should use Cannon carefully engineered miniature and sub-miniature multi-contact connectors. In ½ or ⅓ the usual space, they give you up to 50 contacts, the same number as a standard connector, and still retain **all** the factors of utility, reliability, and mechanical strength found in Cannon's standard size connectors. They are very rugged, easy mating, unusually versatile, neat and compact.

Miniatures—Maximum Dimensions Only 1" x 2"!

Write for Cannon HMC Miniature Connector Bulletin

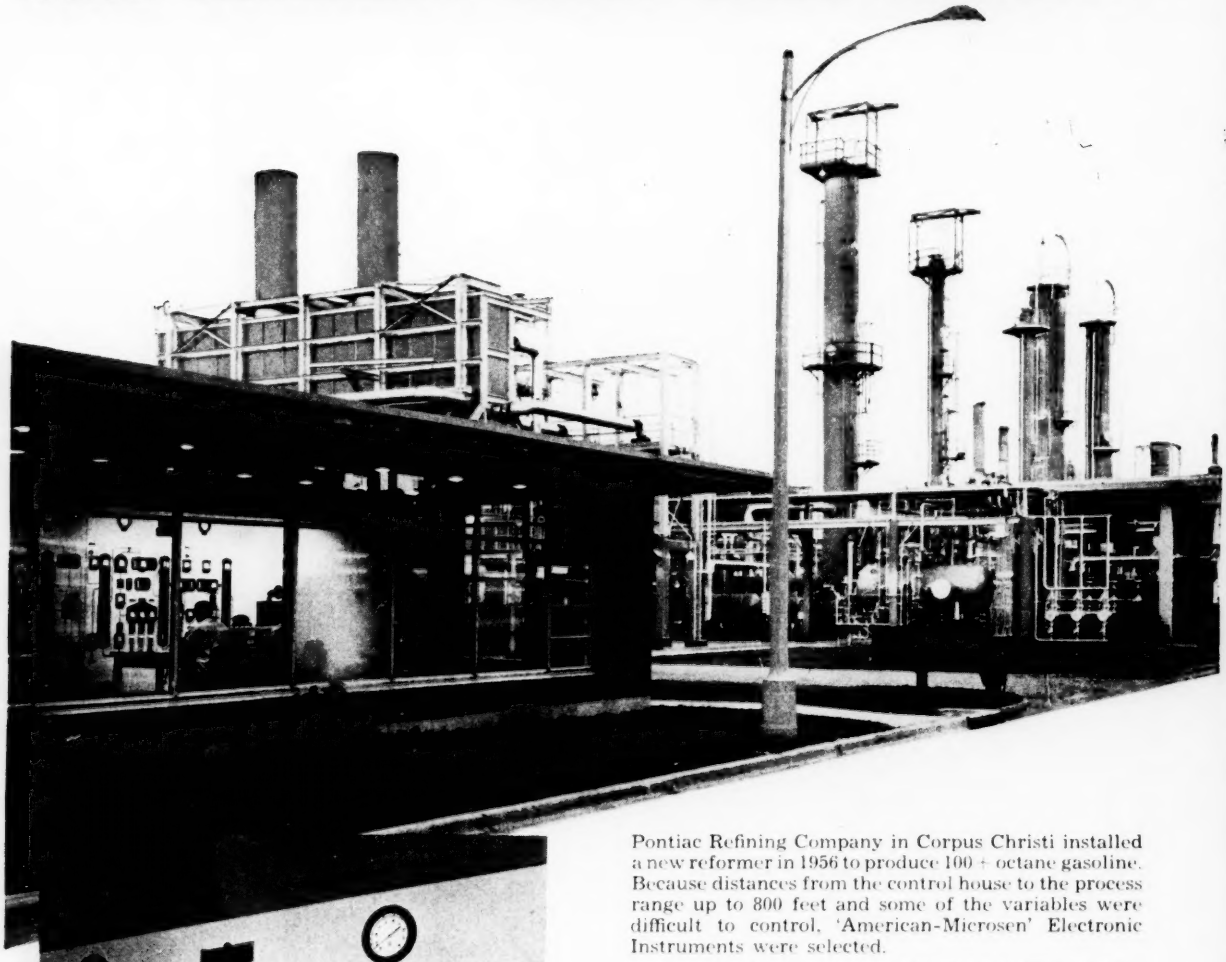
Please refer to Dept. 419

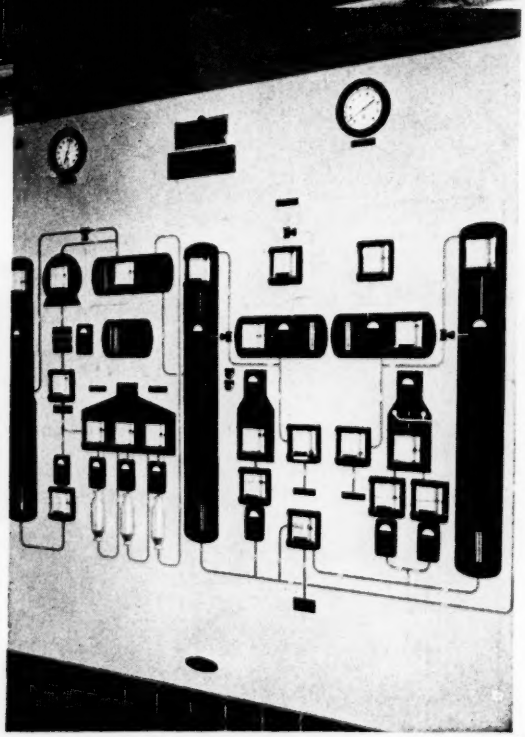
CANNON ELECTRIC COMPANY, 3208 Humboldt Street, Los Angeles 31, California.

Factories in Los Angeles, East Haven, Wakefield, Toronto, London, Melbourne.

Representatives and distributors in all principal cities at your service.

THIS REFINERY GOES ELECTRONIC...





Pontiac Refining Company in Corpus Christi installed a new reformer in 1956 to produce 100 + octane gasoline. Because distances from the control house to the process range up to 800 feet and some of the variables were difficult to control, 'American-Microsen' Electronic Instruments were selected.

The control house contains 'American-Microsen' Controllers for pressures, flows, levels, and temperatures of the process materials at vital stages of the platforming process. Despite the long distances and fast-acting variables, the instruments provide control well within the tolerances required to produce high-octane motor fuel.

Such results are possible because the 'American-Microsen' System is completely electronic, with dc transmission signal that is insensitive to distances as great as 30 miles. The high speed and sensitivity of the electronic design improve the control of all process variables.

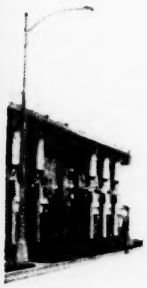
Now in operation over a year at Pontiac Refinery, the 'American-Microsen' System continues to give complete satisfaction — continues to help turn out high grade motor fuel. It is typical of many successful installations, and more and more companies are specifying the system for new plants as well as in modernizing existing processes.

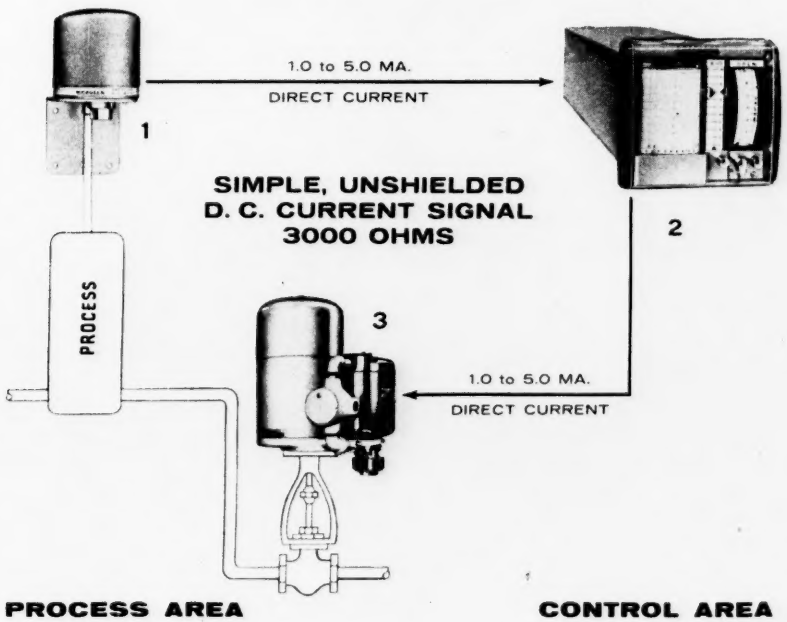
Even though the electronics approach in process control is revolutionary, the 'American-Microsen' System of today incorporates the latest design techniques. Transistors are used for the ultimate in reliability and service life, and printed circuits and miniaturized components provide space-saving simplicity. The complete process control system now uses only three units.

For more information circle **54** on inquiry card.

the modern way to control process variables

AMERICAN-MICROSEN' ELECTRONIC PROCESS CONTROL SYSTEM HELPS PRODUCE HIGH-OCTANE MOTOR FUEL





1. **TRANSMITTER.** 'American-Microsen' transmitters are used for measuring pressure, temperature, differential pressure, liquid level, flow, and other process variables. The "Microsen" balance creates a stable dc signal for long distance transmission. Transmitters have a minimum of bearing pivots or linkages—assuring sensitivity and repeatability of measurement.

2. **CONTROLLER.** A single unit combines all functions of measuring and recording or indicating the input signal; producing the control signal; and allowing manual-automatic process operation. Separate plug-in chassis provides the following functions: A. Records or indicates process variable. Strip or card chart recorder chassis available. B. Produces proportional, reset and rate control actions to regulate the variable. All control settings are calibrated. C. Permits switching to manual operation during start-up or emergency conditions, with true "bumpless" transfer from manual to automatic control.

3. **ELECTRO-HYDRAULIC CONTROL VALVE OPERATOR.** A power unit with position feedback that operates slip-stem control valves. No compressed air is needed. Mountable on standard yokes supplied with conventional slip-stem control valves with bodies of single or double-seated construction, with V-port, parabolic, needle and equal percentage plugs, including valves of 4" stroke, and force available up to 3,250 lbs.

Where required, the 'American-Microsen' Electro-Pneumatic Valve Positioner or the Electro-Pneumatic Transducer can be supplied.

In automating your processes for higher product quality and greater operating economy, you want the better control and simplified servicing provided by the 'American-Microsen' Electronic Process Control System. We invite you to meet with one of our sales engineers to determine the best equipment for your service. Write for literature.

MANNING, MAXWELL & MOORE, INC.

INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

For more information circle 54 on inquiry card.

ELIMINATE THE "UNKNOWN" ERROR FROM YOUR THERMOCOUPLE MEASUREMENTS

MODEL RJ 12
(U.S. PATENT PENDING)

UPLE REFERENCE JUNCTION

Now accepted in most of the nation's missile and aircraft flight test programs, the ARNOUX "HOT" REFERENCE JUNCTION is fast superseding ice baths and bridge compensating networks in airborne applications.

Comparative data prove the Arnoux RJ contributes up to 10°F less error, under severe environmental conditions, than other commonly used techniques. Moreover, it requires no servicing prior to flight, and operates indefinitely without attention of any kind.

Regulation of the nominal 250°F junction temperature is within ± ½°F, at constant ambient. Environmental ambient variations of − 65 to + 200°F cause less than ± 2°F total drift of the nominal. Maximum spread between junctions is 1°F. MIL E-5272A vibration and acceleration cause negligible error.

Operation of the RJ is simple. Thermocouple leads are soldered to the SPECIAL RED AN INPUT CONNECTOR containing pins of thermocouple alloy. Copper output and power leads are soldered to the STANDARD AN OUTPUT CONNECTOR. Special conversion tables for 250°F junction correction are furnished.

Airborne models available in 2, 4, 8 and 12 channels for use with any thermocouples specified. Size: 3" x 3½" x 4¾". Weight: 1¾ lbs. Power: 28V DC, 15 Watts.

Rack mount models also available for ground applications, with capacities of 24, 48 and 72 channels. Power: 115 V AC, 60 cps.

Get the facts . . . write for APPLICATION NOTE RJ1001, a frank analysis and comparison of the three common reference junction techniques.
For more about the Arnoux RJ, ask for Bulletin 400.

ARNOUX

ARNOUX CORPORATION

Designers and Manufacturers of Precision Instrumentation

11924 WEST WASHINGTON BLVD. • LOS ANGELES 66, CALIFORNIA

For more information circle **55** on inquiry card.

Ros Gilbert discusses RELIABILITY

Reliability deliberately incorporated into design, whether the design be for a complete system or for a single component, is the premium in the product that establishes the reputation of the designer and his creation. The customer usually assumes—and does rightfully expect—that the ultimate in presently available reliability is incorporated into any product he acquires. Indeed, this expectancy is so taken for granted that—as the indispensable base note in an orchestral reproduction—it is noticed only if missing.

The successful acceleration of electronics into new areas of application will depend upon our ability to produce reliable equipment. An acute awareness of reliability is therefore more significant than ever in electronic design. An Air Force Colonel recently remarked to the effect that: Present (postwar) electronics is five times as reliable as prewar electronics. But with twenty-five times as much of it, the end result is one-fifth the reliability!

Visions of a bright future in electronics reveal complexities transcending our wildest nightmares. To the imaginatively fertile mind the practicality of mass production of computer elements suggests unprecedented applications already within economic range. Prospects for a successful achievement are literally nonexistent, however, unless the reliability of individual components can be made to yield composite reliability in the great complexity of the ultimate solution. Consider our electronic monsters governing costly processes and the well-being of all the people! Sloppy concessions to reliability would be disastrous. Conversely, absolute reliability would warrant complexity without limit—a most appealing prospect for most of us.

Fate is frequently kind to the venturesome. And she has been particularly kind to those who experimented with, and perfected, transistors and magnetic devices to replace hot electronics components. In the present state of the art the solid state devices can be said to possess "intrinsic" reliability in that they do not suffer from scheduled deterioration as does a thermionic cathode or ionic device. This is indeed encouraging and would appear to spur application into hitherto neglected spheres where the inevitable decay of a tube's cathode formerly limited usefulness. Let not this use be indiscriminate, however, because secondary defects in solid state devices pose other problems which frequently limit the ultimate reliability to an unfavorable degree relative to hot electronics.

One such important defect has been established—the failure of solid state devices is related to intrinsic defects in material rather than to variable life time constants. This seemingly simple yet critical difference fosters the provocative notion of weeding out the culprits through extensive and exhaustive pretesting of components, of sub-systems or whole assemblies and, finally, during check-out in actual operation. Thus, it would seem as if a large, complex system using solid state devices—by the very nature of the beasts—could be made to become increasingly reliable with use almost without limit. An equivalent system composed of elements naturally deteriorating with time will, on the other hand as heretofore, always rapidly approach the critical operating reliability threshold.

Roswell W. Gilbert, Director of Research and Development, Daystrom, Inc., discusses the discipline of reliability.

This notion of perfection in components replacing hot electronics could well be used as the basis for a design discipline applying to solid state systems.

Our discipline would also dictate the use of, for instance, a plug connector, for easy replacement of a component, that is at least as reliable as the component to be used for the ultimate replacement.

Consistently defective materials will be improved by invoking the disciplines of chemistry and metallurgy to produce practically perfectly reliable elements. This process is in fact in high gear today.

Our goal, assuming diligent application of a rigorous discipline in design reliability, is to produce "twenty-five times as much electronics as today, and to make it twenty-five times as reliable."

By applying the latest proven techniques, our well-qualified staff at Daystrom Systems is prepared to take single responsibility of assembling and installing a system to meet your needs. We are currently compiling a file of new applications and papers on various parts of systems, both industrial and military. If you are interested in receiving the file and periodic additions, please write us.

DAYSTROM SYSTEMS

Division of Daystrom, Inc., 5640 La Jolla Boulevard
La Jolla, California Telephone GLencourt 4-0421

analog computor with a NEW TWIST

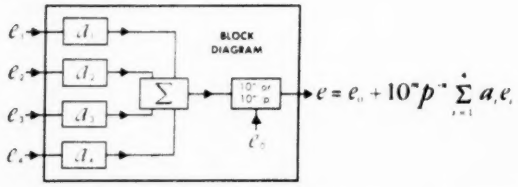
Just twist the knob... decade settings simplify precise parameter programming

In the all-new Philbrick Model K5-U Universal Linear Operator, decade settings replace the usual computing potentiometers to simplify precise parameter programming. Easy to interconnect and use, Model K5-U embodies a variety of operations in one compact, chopper-stabilized unit. This fundamental building block of a general purpose analog computing system permits the analog computor user to extend his design and analysis facilities at reasonable cost.

The Model K5-U accepts up to four voltages and multiplies each by a constant, settable by decade switches to any positive or negative value between 0 and 11.10 in increments of 0.01. These weighted inputs are added together and the sum is then operated on in one of two general ways.

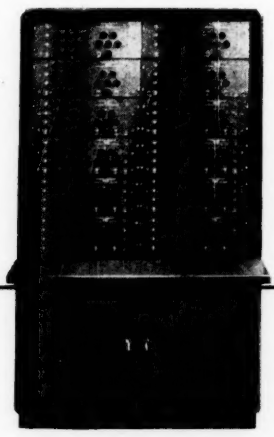
1. The sum may be multiplied by 0, 1, 10, 100 or 1000 and then have added to it a positive or negative index voltage, adjustable from 0 to 50.0 volts in steps of 0.1 volt.

2. The sum may be integrated using any of a wide range of available speeds, viz., 1, 10, 100 or 1000 radians per second. The output voltage may be held at any time, or it may be reset to an initial value which is determined by the index voltage decade setting. The SET-RUN-HOLD modes may be controlled either remotely or manually on the front panel.



Write to George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass., for the name of the PHILBRICK representative in your area and Technical Bulletin IA-1.

- ***Easy to read three-digit decade settings*** — precise adjustment of parameters now possible even during computation.
- ***"Pot-setting" is outmoded*** — time-consuming calibration voltage measurements are eliminated.
- ***Extravagant servo-setting is surpassed*** — simply "read it on the dials" to three figures.
- ***Additional inverting amplifiers are unnecessary*** — individual inputs may be added, subtracted, or removed by the flick of a switch.
- ***Choose your time scale*** — continuous real-time computing, high-speed repetitive operation, and "single-shot" solutions are *all* inherent.
- ***Versatile linear building block*** — Summing Amplifier, Integrating Amplifier, Inverting Amplifier, Initial Conditions, Set-Run-Hold Relays are all available at your fingertips.
- ***Mounting*** — occupies 7" vertically in standard relay rack or enclosure.



Model K5-U retains the convenience, economy and versatility of modular assembly.

GEORGE A.
PHILBRICK
RESEARCHES, INC.
230 Congress Street, Boston 10, Massachusetts

For more information circle 57 on reply card.

a c[redacted]ercially profitable atm[redacted]ere for buyer and seller

Through its exhibits and meetings the show and congress can perform a valuable educational service while providing a commercially profitable atmosphere for both buyer and seller.

With 40% of the exhibit space already assigned, this exposition should early smash the space and num- three predecessors. Congress promises tors alike. A partial

s focussed squarely cy to get there fast, ious challenge—this utomation show be- ndividual and indus-

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for prospective exhibitors and visitors—

★ **One all-inclusive** "package" price for exhibitors **($5.00 sq. ft.)** covers most "fringe" services for **which exhibitor** usually pays extra.

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★ **Exhibitor-sponsored** Clinics on:
- ★ Electronic Computers
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★ **Automation Congress** comprising nine sessions:
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★ **Three 2-day Conferences for top-level executives:**
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4th international AUTOMATION EXPOSITION

and concurrent MILITARY AUTOMATION EXPOSITION

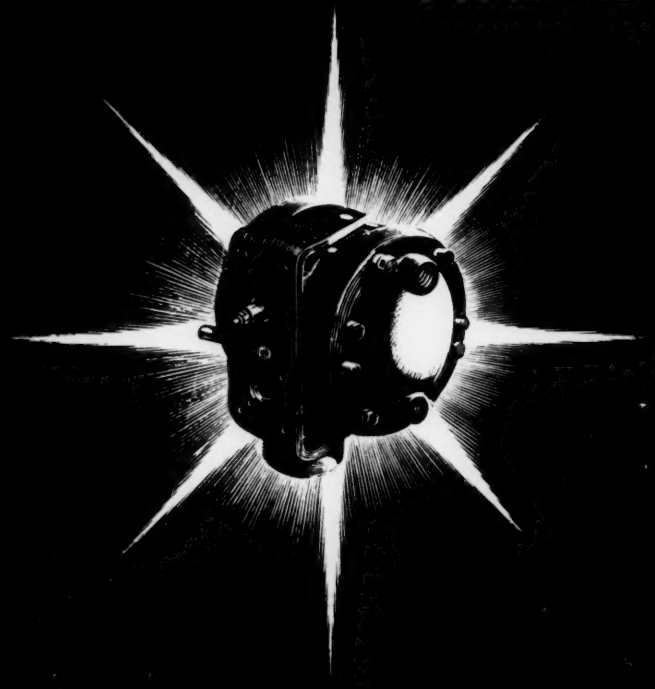
NEW YORK COLISEUM
JUNE 9-13, 1958

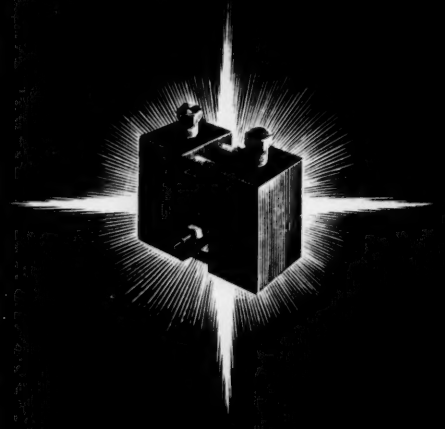
FOR COMPLETE DETAILS, WRITE:

RICHARD RIMBACH ASSOCIATES
845 RIDGE AVE., PITTSBURGH 12

For more information circle **58** on inquiry card.

BARTONS SHINE 'ROUND THE WORLD TOO !





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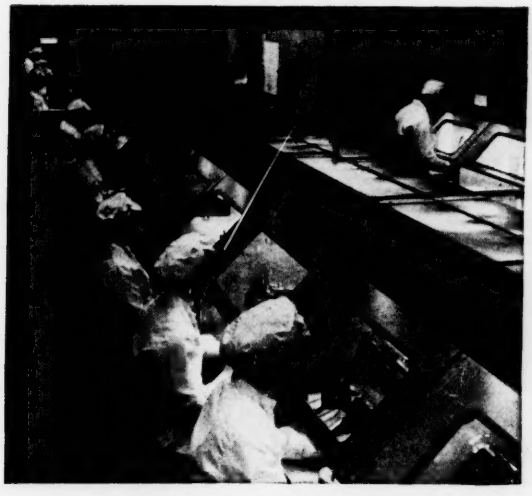

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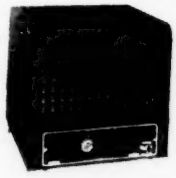

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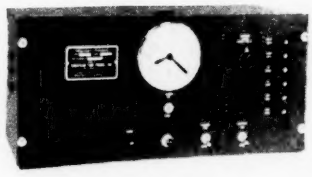

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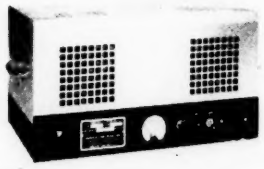

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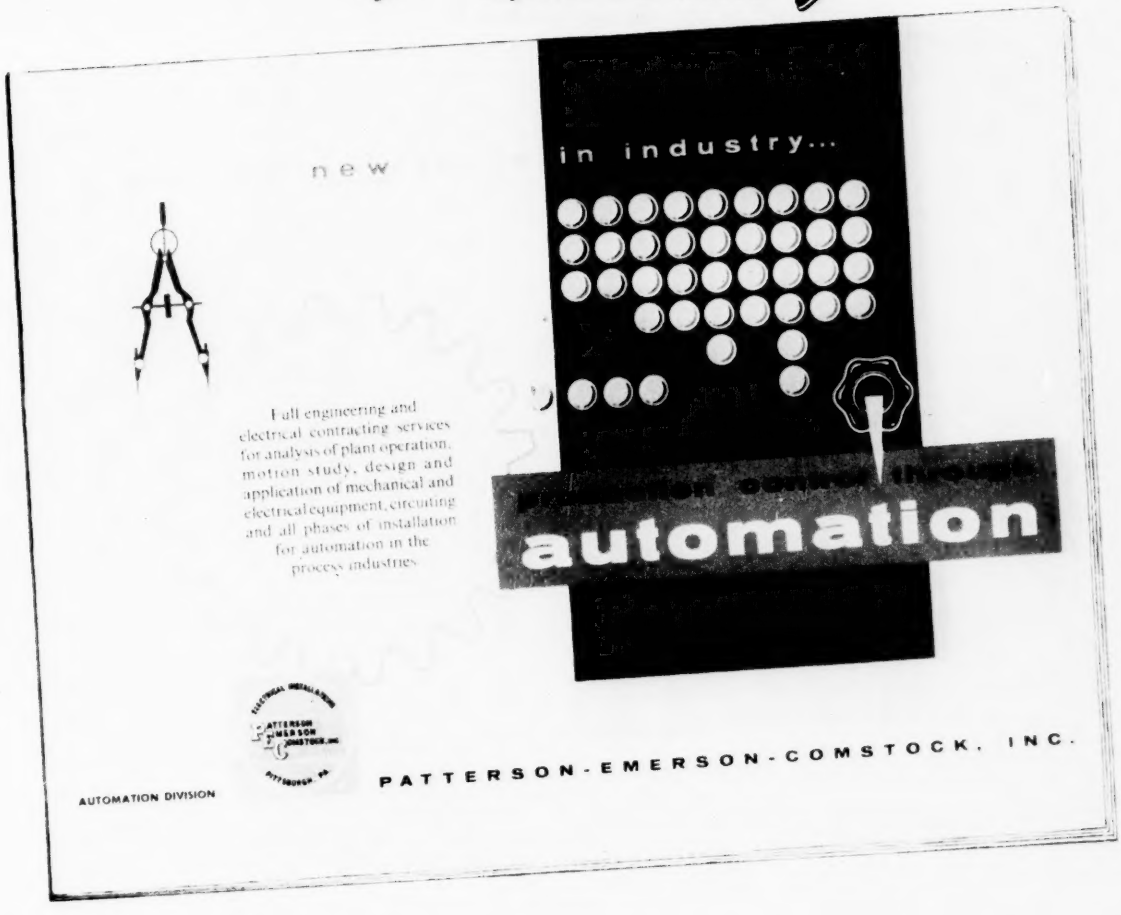
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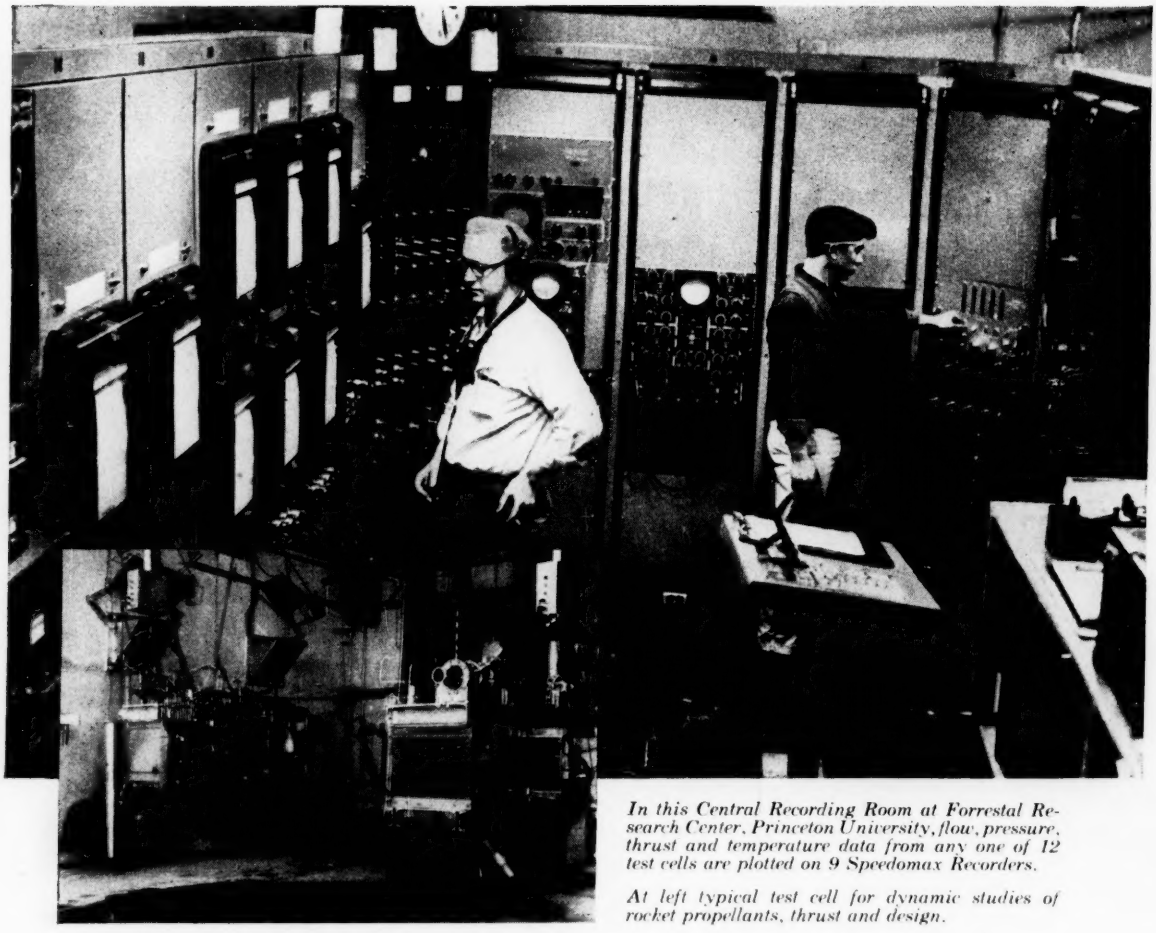

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SYSTEMS OR HARDWARE?

STRANGE things are happening today in the field of measurement and control. A new concept—the systems concept—is causing many organizations to change established business patterns; is causing instrument manufacturers to compete for any type of systems work, including systems with little of their own hardware; is causing the formation of literally dozens of "systems" firms who are talking and acting more like instrument manufacturers than system firms. The systems concept is making instrument manufacturers act like systems firms, and systems firms act like instrument manufacturers; it is causing everybody to compete for everything in the name of "systems."

This systems bandwagon, on which our entire industry is scrambling, is at present heading in a demonstrably dangerous direction. The concept is causing competition between groups that should be cooperating: it is forcing instrument manufacturers into systems work and systems firms into instrument manufacture—and by so doing it is causing both groups to use the concept more as a means for selling hardware than for solving systems problems. Thus the systems concept is being used today to debase if not destroy itself, a not unusual result of frantic acceptance of sensational concepts by large groups.

"Systems engineering" and "automation" have much in common. Both, according to a large segment of the American trade press, are going to revolutionize the process industry and the instrument market: both are going to serve a happy, cultured humanity with the computer-controlled output of productivity optimated manless plants and factories. Both involve "rethinking" concepts based on the new technologies of our times.

But the systems engineering bandwagon has rolled much farther than its automation predecessor because it added a theoretical basis to the glorious fancies—it equated the past systems experience of the aircraft industry to the future possibilities of the process industries. However, this theoretical justification, although universally accepted, ignores two points of fact that are emphasized again and again in the factual articles in this issue:

First, the aircraft and missile are masses in space. The variables are few in number (forces, masses, distances, motions). The aerodynamic equations are well-known, with constants obtainable in wind tunnels. Mathematically, the complexity of the process problem is several orders of magnitude above that of the comparable aircraft problem and, in addition, all workers in the process industries are familiar with the idiosyncracies of unit process operations—even two identical processes seldom operate in identical manner.

Second, the military aspects of the aircraft problem overshadow the economic aspects. A million dollars can be spent to solve one aerodynamic problem; industry cannot justify the expenditures of huge sums without conventional economic payout justification—even on an experimental basic-research approach. Thus the use of the experience of the aircraft industry as a basis for a new theory for the process industries ignores two points of fact—the far greater complexity of the process problem and the requirement of economic justification.

Reasoning from this aircraft-industry base, the voluble proponents of systems have envisioned complete systems-engineered process industries. To all who have accepted this concept without question, we offer the following comments of Charles Hitch, of the Rand Corporation, on the kindred subject of Operations Research:

"The typical good operations researcher, fresh from comparing fire-control systems or applying queuing theory to traffic problems (but) with no special knowledge of economics . . . would be next to useless to a (government) planning commission . . . I have no evidence, in spite of optimistic speculations, that operations research has as yet much to offer at the level of national planning . . . Difficulties increase and our special competence diminishes by an order of magnitude with every level of decision making we attempt to ascend . . . High-level jobs have allure, but level does not measure importance, and is inversely correlated with tractibility . . . Nothing is as likely to bring operations research into disrepute as exaggerated hopes and claims."

The analogy of these remarks to the field of systems engineering, as applied to chemical processes, is left to the reader, who is referred to the articles in this Special Issue, which clearly show the unreality of the optimized chemical plant that appears in the trade literature, and the fantastic complexity of realizing the mathematical model of the plant. The articles also show that industrial managers demand economic justification before opening their arms (and pocketbooks) to the systems concept. All these articles are grouped under the heading of "Theory Versus Practice," and include those by Van Zandt Williams, Arthur Rose, A. C. Brodie, and Lester Driskell.

The Appeal of Systems Engineering

No amount of reasoning will stem the systems flood. Why?

R. H. Bristol, President of the Foxboro Co., pointed out recently: "There is a trend toward more so-called packaged equipment, particularly if we include systems and computers. There are many reasons for this trend, arising out of the complexity of the equipment . . . and a desire to have the responsibility for results localized."

K. W. Peterson, Sales Manager of the Industrial Controls Div., Manning, Maxwell & Moore, reports: "We are in a good position to observe the tendency on the part of our customers to require integrated or packaged systems . . . Our customers don't want components; they want answers. Often the answer involves a conglomeration of equipment from many suppliers . . . However, this does not imply it is a standardized system for which there may be repeat orders . . . The engineering service provided may range from an insignificant amount to many months of design and development . . . The problem is to give a reasonable amount of service in order to allow room for a reasonable profit."

These comments clearly reveal the reason *why* instrument manufacturers are paying more attention to systems—but they do not answer the questions that appear immediately—particularly how to sell (and charge for) a system comprising more products of another manufacturer than of your own; how much engineering can be justified on a system; how to serve honestly while selling profitably.

More than moral issues are involved when the instrument manufacturer goes into systems engineering and the systems firm into hardware production. The problems and objectives of instrument manufacturing are, as shown by the articles in this issue, basically different from those of systems engineering although enough overlap in technique exists to have caused the present confusion. The failure to recognize these differences has already caused great financial losses to instrument manufacturers (now burdened with expensive systems divisions facing strange and complex problems), to systems firms (now faced with urgent necessity for instrument manufacture with its unique and complex marketing problems), and to industrial customers of both (now wondering if the systems concept is being used to push hardware sales).

This is the now obvious trend despite the fact that the systems concept is sound, despite the fact that instrument manufacturers can and should practice systems engineering in certain fields and on certain systems, and despite the fact that the systems firm can and should benefit from hardware production resulting from systems projects. Under proper lines of recognized responsibility, the systems firm and the instrument manufacturer should and could work cooperatively to serve industry with modern techniques to the benefit of all. But such cooperation of instrument manufacturer, systems engineer, and customer can be based only on a recognition of each party of the responsibilities of the others. Can we define these limits of responsibility so that the needed cooperation can be effected?

There Are Two Types of Systems Engineering—Basic and Applied

There is no need to attempt to define the term systems engineering in a manner acceptable to everybody, as Chalmer Jones brings out in his article herein. Systems engineering is, obviously, the engineering of a system. It usually, but not always, includes dynamic analysis, mathematical models, simulation, linear programming, data logging, computing, optimating, etc., etc. It connotes an optimum method, realized by modern engineering techniques. Basic systems engineering includes not only the control system but also all equipments within the system, including all host equipments for the control system.

Applications engineering is—and always has been—all the engineering required to apply the hardware of a hardware manufacturer to the needs of the customer. Such applications engineering may include, and always has included where needed, dynamic analysis, mathematical models, simulation, linear programming, data logging, computing, and any technique needed to meet the end purpose—the fitting of an existing line of production hardware to a customer's needs. *This is applied systems engineering.*

Note that applications engineering and systems engineering use similar *techniques*, but there is an obvious, basic and essential difference—applications engineering applies to the products of a hardware manufacturer; systems engineering applies to the needs of the entire system of the user. The system usually—but not always—requires the hardware of many manufacturers, and it is here that the subject of legitimate responsibility rears its ugly (and up to now ignored) head. Applications engineering is obviously the responsibility of the hardware manufacturer—but to whom should accrue the responsibility for a system that includes the hardware of many manufacturers?

We shall try to show that recognition of the distinction between basic and applied systems engineering

would not only eliminate the many uneconomic practices that are becoming common, but would actually protect the systems concept from those who today are unknowingly killing it in the name of systems engineering.

The systems engineering firm could renounce instrument manufacture with provision for benefiting from new hardware developments associated with the systems project. As it is admitted that systems engineering flourishes best when unencumbered with hardware sales, this is no Utopian concept.

The instrument manufacturer could restrict all systems engineering to systems where his products are in the majority and where he has had experience. As he has suffered whenever he failed to do this, this also is not Utopian.

Since each could now admit to the responsibility of the other, the systems firm could recommend the instrument manufacturer on systems needing applications engineering, and the instrument manufacturer could recommend a systems firm for any system needing more than applied systems engineering. This is where the distinction between applied systems engineering and basic systems engineering could lead.

We believe that the starting point for cooperation rather than competition between systems firms and instrument manufacturers is recognition of this distinction. The systems engineer must leave hardware manufacture and applications engineering to the instrument manufacturer, and the instrument manufacturer must leave basic systems engineering to the systems engineer, recognizing that the major difference between the two is in the character of the system—does it require hardware of primarily one manufacturer or of many manufacturers? Does it require development and prototype equipment or standard equipment? Does the customer need consultation or hardware?

The Basic Systems Engineer Should Benefit From Hardware Developments

An unsolved problem is to devise a means whereby the independent systems firm can benefit from the hardware developments that might arise from a systems project. Here the answer might be a small, select organization of systems engineering firms, perhaps called the *Systems Engineering Council*. Membership in the SEC would be restricted to groups that renounce hardware production, that are skilled in prototype development, consultation, and systems work in some field of activity. Plant constructors, fabricators, individuals, consultants and many systems groups would qualify. The SEC would act as a clearing house and directory of basic systems-engineering talent at the service of industry and the instrument manufacturer alike. Its code of ethics would state that the systems group has no vested interested in selecting the hardware of any manufacturer. In turn, the SEC would guarantee and protect a licensing agreement that would permit the basic systems group or individual to benefit from hardware developments associated with the project. The SEC could provide legal counsel to assure the basic systems firm, or individual, of full protection in this licensing arrangement.

The mere existence of a group of basic systems-engineering firms would serve to define the distinction between basic and applied systems engineering.

This suggestion is offered to the industry as one means to halt the present trend whereby instrument manufacturers are recklessly seeking systems contracts that are far removed from the past activities of the firm, and whereby systems firms are desperately trying to find marketable products in order to keep alive. A firm code of ethics and a Systems Engineering Council might translate this presently uneconomic and undesirable competition into harmonious and progressive cooperation. Such a development should appeal to the instrument manufacturer, who once again could safely turn his attention to his breadwinning hardware, whose systems division would then concentrate on problems of application of that hardware (including needed analysis of the hardware itself), and who would use a consulting member of the SEC for large "systems."

It should appeal also to the systems engineer who could profitably perform the work he wants to do, and who could benefit from his SEC-protected licensing agreements with the manufacturer.

And it should appeal to the customer, who could then be assured that he is receiving objective service from all segments of our industry.

The Customer Also Has An Interest

Again and again in the articles in this issue it is brought out that someone within the plant must know the plant, must be familiar with its operation and control, and must know how to cooperate with any outsider at work on the system. The instrument engineering department of every plant, whether called systems engineering, instrument engineering, efficiency engineering, combustion engineering, or any other term, has the final responsibility for the measurement and control aspects of the plant. Perhaps the entire future of systems engineering rests on the plant instrument engineer. In the meantime, the instrument manufacturer and the systems firm must define the limits of their responsibility so that both can serve the plant and the industry.

To the instrument engineer who feels bewildered at all this talk of systems, we conclude by pointing out the remark of P. M. S. Blackett, President of the British Association of the Advancement of Science, in his address to this year's meeting of that association: "Even today the biochemist cannot teach a chef how to cook a better omelet." So always will there be art in science and engineering, the beautiful art that comes only of experience and practice. MHA

Comments from the field on

OUR 30TH BIRTHDAY

Your vision has been vindicated . . .

E. R. Mellen

"My experience in the instruments industry dates back to the time of World War I. It is interesting to look back and see how far we have come in these years. I recall the first edition of *Instruments* magazine. We discussed it among our executive group and the opinion prevailed that Dick Rimbach was embarking on a program of limited scope and activity: in fact, we questioned how you could hope to obtain the necessary advertising to provide the necessary support for this publication from the limited number of companies in the strictly-speaking "instrument" industry. I think your vision has been vindicated by what has taken place in the thirty-year period. Certainly the growth of the instrument industry has been outstanding!

"In that connection, we must now take into account the many different forms of instrumentation and related applications covered under the wide scope of systems, computers, and automation. It is my opinion that the instrument, control, and automation industry is only on the threshold of further great advance in the years ahead. There will be ups and downs in this period, as we know from past experience. The twelve years since the end of World War II have shown a most remarkable growth — the greatest of any period in our history. Associated with the instrument industry, there have been and will be many advances in chemistry, metallurgy, physics, etc., all of which, have an influence on the types of instruments to be made in the future. We have only started in the fields of automation, computers, systems, and control and the growth factor is difficult to visualize at this time."

E. R. Mellen, Chairman
Daystrom-Weston

After sixty years—only 40% efficiency . . .

E. G. Bailey

"James Watt, an apprenticed instrument maker, was working on a Newcomen engine in the laboratory of the University of Glasgow when his observations led to the invention of a steam engine with a thermal efficiency of four percent, or four times that of the engine he was testing.

"In 1900, after many improvements by many people over the intervening 135 years, the steam engine and boiler efficiency had reached about 12 percent. Now, after an additional sixty years and with the aid of steam turbines, stage heating, supercritical pressure, high superheat, and two stages of reheat, we have a thermal efficiency of about 40 percent, or only ten times that of the Watt engine.

"I implore the instrument makers of today to apply instruments, meters, and automatic control to all kinds of power and process equipment in such ways as to improve the efficiency and usefulness of such equipment. This should be done as economically as possible, with a minimum of well adapted components having great accuracy and reliability.

"The instrument makers, and especially their practical service men, should emulate James Watt by observing and inventing useful improvements in the equipment to which the instruments are applied."

E. G. Bailey, Founder
Bailey Meter Co.

Thirty years ago . . .

Richard P. Brown

"Thirty years ago, when I was President of the Brown Instrument Company, now a division of Minneapolis-Honeywell Regulator Company, I read your first issue of *Instru-*

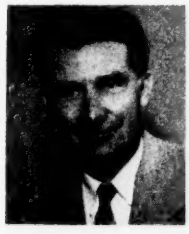
ments . . . Ever since then, for thirty years, I have been a reader of your journal, now broadened in its scope and entitled *Instruments and Automation*.

"It is my sincere hope that *Instruments and Automation* will continue to be a fine publication over the next thirty years."

Richard P. Brown, Founder
The Brown Instrument Co.
Now a director of
Minneapolis-Honeywell
Regulator Company

Rating methods are not satisfactory . . .

G. G. Gallagher



"The new concept of systems engineering will make it necessary for each manufacturer of pumps, compressors, etc., as well as instruments, to accurately specify the performance of their equipment. This is needed so the Instrument or Systems Engineer can intelligently select the proper instruments and controls for a given system.

"Present methods of rating equipment are not satisfactory. I personally feel that before we can make instrumentation and control a full science, instead of the present art, it will be necessary to establish a separate testing authority, or authorities, providing services similar to those performed by Underwriters Laboratory for electrical equipment. This way a non-biased standard set of performance data could be made available to the trade for each instrument or component that a manufacturer chose to present for test.

"In this new concept of System Engineering it will also be necessary for the Instrument or System Engineer to broaden his knowledge of many other items of equipment in addition to instruments and controls.

"As in the past, *Instruments and Automation* can make a real contribution to this important new trend by sponsoring articles and ideas leading toward development of the necessary testing authority, and preparing the Instrument Engineer for his broader task."

Glen G. Gallagher
Chief Instrument Engineer
The Fluor Corporation, Ltd.

You have earned our thanks . . .

D. E. Hostedler

"Thirty years in world history is an insignificant period of time; but in the evolution of instrumentation and automatic control, it encompasses a major span of the total. The growth in the industry during this time has been phenomenal, and it has taxed the abilities of most of us to keep abreast of new developments. *Instruments and Automation* is to be congratulated on its ability to lead instead of just keep pace, from the start, in dissemination of the knowledge which assisted this growth. You have earned the thanks of all of us who have elected this field as our interest and career.

"From an inspection of the industry's growth curve ten years ago, we would have expected to see the beginning of a 'leveling off' typical of all such curves. This has not appeared and, with the new techniques, equipment, and applications appearing each day, it doesn't seem that it will.

"There have been several steps, or phases, of instrumentation development through these years, each of which resulted in a new surge of growth, a new expansion in the field of instrumentation . . . We are now witnessing the start of another development phase. In past years the use of computers was limited to highly specialized areas, with gunfire control as a good example. More recently it has been recognized that the use of computers can be applied much more generally to many systems of control. In my opinion this development can take us to a new plateau in the advancement of instrumentation.

"No longer, in this new development phase, can the manufacturer merely sell the hardware in which each piece can be rated on its mechanical or electrical merits alone. Computers cannot be sold as hardware. They must be designed and applied to do a 'system' job. Knowledge of what they must do is necessary before they can be designed to do the task. So much depends upon the attitude of manufacturers toward establishing thoroughly competent systems engineering groups or departments. A complete collaboration between the purchaser and the manufacturer is also needed, but the success or failure of the development rests with the manufacturer's ability to take the data and translate it into the complex mechanism that will produce the required results.

"From past experience we expect the manufacturer will be in step, or a bit ahead. Some already have established the personnel to do so. We also are confident that *Instruments and Automation* is in its usual position of a leader for the industry, and will be publishing the technical knowledge needed by the engineers who will make this step an important one. May its 30th Anniversary be another well marked milestone."

David E. Hostedler, Supervisor
Instrumentation Engineering
Foster Wheeler Corporation

Instrument departments needed to match the laboratory . . .

A. H. Peterson

"Recently I was visiting a very large industrial research laboratory and was being shown its fine facilities. I observed that they did not

". . . Your activities have contributed mightily to our present high standards and progress."

have an instrument stockroom, so I inquired about this. The answer that I received was that they didn't need one. If you wanted something (say an X-Y recorder at $2,000) then you ordered it, since there was plenty of money at hand. I then asked what happened if delivery took six months. This was disposed of by saying that you looked around the laboratory (of over 1,000 people) until you found one. Then this person whose lab contained the X-Y recorder, being a reasonable scientist, would let you have it (never having seen you before).

"Perhaps the reader detects chaos and inefficiency in the foregoing example. Yet this primitive method seems to be the rule in large laboratories. This lack of system worked beautifully twenty-five years ago when that laboratory had only twenty-five people, but it doesn't work in a modern king-sized laboratory.

"This disorganization contributes greatly to the high cost of research in ways other than costly duplication of equipment. When a researcher has to wait six months to get an instrument to check his ideas, he either abandons the idea, tries to get an idea that fits the instruments on hand, or spins his wheels trying to dream up another way.

"Plant instrument departments have been running with great success during the last decade. A research laboratory with its considerably different problems, can also organize an effective instrument department.

"This problem—providing an instrument department to match the modern large laboratory—is an important current problem that needs resolution.

"I wish personally to congratulate *Instruments and Automation* for vigorous promotion of the entire field of instrumentation during the past thirty years. Your activities have contributed mightily to our present high standards and progress."

Axel H. Peterson, Head
Department of Instrumentation,
Mellon Institute of
Industrial Research

Management will become more dependent on the instrument engineer of the future . . .

N. L. Isenhour

Each year it becomes more evident as the development of the management-tool-type of instrumentation (data handling, computers, end point analysis and control, etc.) continues, that the instrument engineer of the future is going to be a busy fellow keeping up-to-date on the latest developments and their application to the management, manufacturing and chemical processes of a plant. This will require that he have, in addition to a thorough knowledge of the technical aspects of a plant, a complete and comprehensive understanding of the management process and the requirements for quick and accurate decision making by the manager.

"Assuming the instrument engineer of the future is well prepared technically and has a complete understanding of the application and limitations of the available instruments, he then must re-orient his thinking to include basic factors of the management process, including accounting practices, inventory control, long-range planning, and how and why decisions are made for capital expenditures such as equipment replacement and plant expansion.

"As the automatic factory becomes a reality, management will, by necessity, be required to depend more and more upon the instrument engineer's ideas and recommendations as one of the major factors in their long range planning. The engineer who has the 'know-how' to supply management with these services will surely be in an excellent position to advance in the plant organization.

"I also predict that *Instruments and Automation* will continue in the future, as in the past, to be a most valuable source of instrumentation information."

N. L. Isenhour, Superintendent
General Engineering Depts.
Oak Ridge Gaseous Diffusion Plant
Union Carbide Nuclear Co.

There is a continuing need for education . . .

H. C. Roberts

"Three decades ago, precision instruments and controls were largely laboratory devices; in the mill, the factory, and for the refinery a few scattered single-purpose instruments supplemented the judgement of experienced men. Modern industry could not operate without modern instruments; more sensitive, more

accurate, more rapid and less fallible than human operators, they make possible new operations and new products unknown a generation ago. Not only the processes of industry, but the techniques of communication and accounting, the operations of transportation and even of war have been truly revolutionized. It is a most impressive record of accomplishment in education, in development, and in production.

"What of the future? There is a continuing need for education at all levels. Our work employs physical principles most of which have been known for many years; yet there are still too few people engaged in the imaginative application of these principles. The present-day control loop encloses not only a manufacturing process, but an inventory as well, and that of tomorrow will include some administrative action.

"Congratulations to *Instruments and Automation* on its thirty years of accomplishment; best wishes for the future."

Howard C. Roberts
University of Illinois

Congratulations for the past—and eyes for the future . . .

J. G. Kerley

"Congratulating the staff of *Instruments and Automation* on its thirtieth anniversary gives the Instrument man a bit of pleasure he rarely enjoys: looking backward. He looks back with admiration at the foresight, faith and fortitude of the founders of a pocket-sized journal devoted to industrial measuring *Instruments*. When, a few years later, its scope was enlarged to cover "Measurement *and Control*" it heralded the birth of a new profession—one so vigorous and versatile that within a score of years it would embrace entire manufacturing processes as systems. Always a step ahead, the voice of that profession has again changed its scope—"Instruments *and Automation*"—to encompass the ever broadening field, and has grown into one of the foremost technical journals.

"Then he looks at his profession itself and realizes how over those three decades it has dignified mankind: how it has extended man's senses, augmented man's muscles, calculated man's laborious problems. He thinks about its method and products and how they have increased man's control over the earth's resources not only on the land but in its bowels, on and under the surface of the seas, in the air, and even the space beyond. Then he realizes that the sky is not and never has been the limit of his profession. Somewhat encouraged, he turns his eyes ahead again to an equally challenging future."

J. G. Kerley
Instrument Engineer
Shell Oil Company

Problems may be more complex than anticipated . . .

J. Ward Percy

"With the rapid development of data handling instruments and equipment, much stress is being placed upon systems. It is my personal opinion that the application of systems engineering to the process industries may create problems more varied and complex than its more voluble proponents presently anticipate. In such a situation, *Instruments and Automation* will do much in bringing these problems up for discussion, thus aiding in their solution."

J. Ward Percy
Supervising Technologist
Applied Research Laboratory
United States Steel Corp.

Technology moves fast—we know penalty for lagging . . .

O. L. Updike

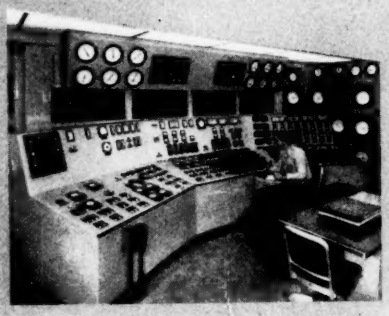
"Technology moves fast today, as we engineering teachers well know. The instrumentation field demonstrates this forcefully. Growth catalyzes itself as theories lead to hardware designs, which in turn lead to more experimental work and make the experiments more productive. Nuclei of theory such as semiconductors and information theory produce explosively rapid developments.

"This is a positive feedback system—with a large 'random' component from basic research. Prediction of a future state for such a system is risky; the autocatalytic mass can produce a hot spot anywhere. Even such exotic things as monolithic control systems complex enough to integrate entire groups of plants and to use economic data and predictions as well as direct technical measurements are not far ahead as 1958 begins.

"Engineers to design, build, and run the systems of the future cannot be taught the technology of tomorrow *in detail*. We don't know it in detail. But they can be taught its scientific basis, and the fundamental principles for analyzing problems not yet formulated. The best engineering schools are more and more stressing basic science, with the principles of analytical and synthetic thought. They rely on our growing literature and on industry's vast facilities to continue the never-completed job of educating the engineers.

"The education for tomorrow—and the day after—is a tremendous task. Journals like *Instruments and Automation*, as well as educators both in schools and in industry, have a real challenge to run fast enough to keep up—and we all know the penalty for lagging."

O. L. Updike
Assoc. Prof.
Chemical Engineering
University of Virginia



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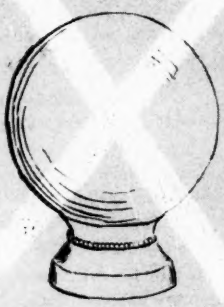

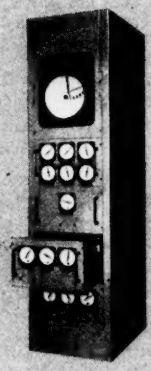

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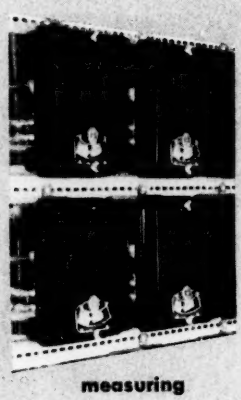

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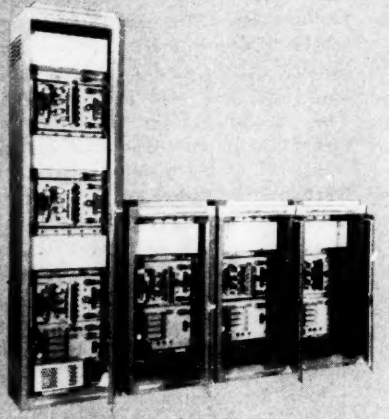

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What and Where is the

A report of efforts made to provide systems engineering for the process and industrial control field.

A. C. BRODIE
Badger Manufacturing Co.*

MODERN, continuous, chemical process plants employ an enormous *number* of closed-loop control systems with considerable engineering time spent on the design of the necessary, but separate, instrumentation. However, complete system design for control of process variables is rarely based on scientific method.

The miracles accomplished by modern aircraft and fire-control systems would have been impossible if the philosophy of closed-loop thinking had not been explored and developed into a working set of analysis and synthesis techniques which characterize the servomechanism field. To the control engineer experienced in the design of military systems, process control systems seem ripe for application of these same techniques and would seem almost certain to be improved by substituting the calculative for the empirical design approach.

The Search for Clients

The key to unlocking so much in the closed-loop control field is essentially mathematical, and thus almost invariably requires higher education. The broadest extension of these closed-loop principles has come to enjoy the name "Systems Engineering" wherein the elements in the loop may lie in a number of different engineering areas—for example, chemical, mathematical, electrical, etc. A rational system design must make use of knowledge which straddles the entire field of engineering. As a consequence, a further broadening of educational background is required for an engineer to qualify as a "Systems Engineer."

It was with this category of personnel that the author's company* started its search for clients in the processing field. Stated briefly, the company offered an engineering service for plant control systems which would predict system performance, determine optimum instrument settings and re-specify process equipment for better controllability—all this before funds are irretrievably committed in equipment purchase. The company was willing to undertake the design of complete plants or any fraction thereof.

The results of this effort have been tabulated under an arbitrary breakdown in Table I. The area of contacts did not extend west of Chicago, but it is felt that the reactions are representative.

The Response

The over-all response did not live up to expectations.

It is felt by the author that, although there are a number of contributing reasons for the indifferent reception, there is a basic technical reason that warrants clearer recognition. The closed-loop systems design, as exemplified by the servomechanism, must meet two environmental requirements—first, minimum response to unwanted signals (extraneous disturbances) and, second, a high order of response to "wanted" signals, the system inputs. In other terms, the servomechanism should be sluggish to random disturbances and stiff toward desired inputs. Unthinking design to meet one of these conditions without consideration of the other would not produce an acceptable servo system.

This generalized problem statement does not fit the process control system. Essentially, a process control system must meet only the first of the foregoing requirements, namely elimination of the effect of outside disturbances on the controlled variable. The unit operator varies the set points infrequently as compared with the response times characterizing the system dynamics. Continuous chemical processing presupposes an unchanging set of process conditions throughout the plant. From time to time, variations in feed stock or a major processing change will prompt a new set of figures and so cause a change in set point. However, such changes are, under present operating conditions, manually inserted at long intervals. Except in unusual circumstances, the transient time before the new set of desired values is reached

*Author was with Feedback Controls, Inc., when this work was written.

Systems Engineering Market?

TABLE 1—SURVEY OF MARKET FOR SYSTEMS ENGINEERING IN PROCESS CONTROL

Company Type or Product Manufactured	Number of Companies	Size	Positions and Number Visited in Each Category	Summary of Individual Attitudes	Major Obstacle Seen by Persons Contacted
1. Chemical Manufacturer	10	6 Major	Chief Instrument Designer (4) Research Engineer (2) Chief Engineer (4) Director, Systems Engineering (2)	Generally great interest among the instrument engineers; Systems engineering groups fully as knowledgeable as author's own company. Other than these groups, both understanding and interest definitely limited.	Lack knowledge process dynamics; Measurement means limit; No time available for systems design; Sell management
2. Petroleum Processors	9	8 Major	Instrumentation Engineer (5) Director Instrumentation R&D (3) Chief Engineer (2) Ref'y Instrumentation Engineer (1) Purchasing Agent (1) V. P.—Manufacturing (1) Operators (2)	Same as in the chemical field with, once again, engineers with instrumentation responsibilities showing interest. Other engineering, purchasing or manufacturing people displayed little to no understanding and very limited interest.	Process instrumentation in hands of contractor; Sell management; Do all work in own organization; Not economic
3. Mechanical Contractors (Chemical & Petroleum)	7	5 Major	Chief Engineer (2) Manager R&D (1) Chief Instrumentation Engineer (4)	Only in the R&D division was any interest displayed; others very little.	No funds available from client for systems service
4. Process Contractors	3	2 Major	Chief Engineer (2) Chief Instrumentation Engineer (1)	Considerable interest was found in this group by all parties with a recognition that they have much to learn before reaching a full understanding of techniques involved.	Prefer use members own organization
5. Other Manufacturers (Steel, Glass, etc.)	7	6 Major	Manager, Engineering Research (5) Superintendent of Operations (1)	Again, great interest was apparent, with, however, little understanding of the techniques involved.	No obstacles
6. Power Plant Designers	3 Nuclear 1 Conventional		Manager, Engineering Development (3)	Considerable interest and understanding.	No obstacles
7. Wind tunnel, engine test facilities (air frame & engine manufacturers, architect—engineers)			Well established procedures and understanding already in existence whereby "Systems Engineering" is recognized and requested.		

NOTE: A number of process instrument manufacturing companies were contacted, but since they are primarily suppliers to this same market they are not entered in the tabulation.

is negligible in length compared to the time on-stream when the final condition is reached.

Thus, the process control system can be more accurately likened to the "regulator" class of closed-cycle control, rather than the servomechanism. Though both can be analyzed by the same methods, in the case of the regulator such analysis is often academic and a needless expense for a low-order regulator, namely, one which is linked to an apparatus or process with built-in ability to absorb the effects of external disturbances.

There is a qualification necessary here. Built-in

"Process dynamics are only rarely known"

process resistance to disturbances is only of value for disturbances which enter "upstream," so to speak, of the over-size process equipment. A disturbance at the controlled-variable end is very poorly countered by a system incorporating excess process capacity or resistance. Temperature, pressure and level control systems invariably interpose their large system capacities between the variable of interest and the disturbance. Flow control systems are the contrary case, and the designer has no recourse but to go to a high-precision control system. This latter consideration has resulted in considerable application of closed-loop techniques to flow controllers—principally by the instrument manufacturing companies.

Built-In Regulation

Once the classification of the process control loop in the regulator class is accepted and the existence of the two possible approaches to achieving acceptable control is recognized, an economic distinction can be made. Unless operating conditions are severe (high temperatures and pressures, corrosive chemicals, etc.), the cost of arbitrarily incorporating large excess capacities and power in a process often is less than the cost of analysis conducted by a "systems engineering" group. Problems examined by the author and his associates, though not all carried to ultimate dollar savings, bear out this conclusion—again these studies were restricted to the more routine processes. In addition, the time for system analysis is frequently not available, while an arbitrary oversize is quick and generally accepted as good process design. Also, vessel sizes are often determined by other requirements: for example, reflux accumulators are sized to allow for a temporary cooling water failure; tower bottoms capacity is established by providing for a possible temporary loss of bottoms pump, etc. As a rule, these requirements are far in excess of the optimum size determined by a control system analysis and thus reduce the economic benefit from a systems analysis.

Vital Process Dynamics Unknown

To perform a system analysis, a knowledge of the process dynamics is essential. These are only rarely known. Because all plant design is presently based on static conditions, there has been no reason in the past to delve into process or process equipment dynamic characteristics. It is, furthermore, admittedly a long-term project to portray with any degree of reliability the dynamics of chemical reactions—consider the variety of reactions that occur in a polymerizing vessel and the difficulty of relating production of any one component in the polymerization chain of reactions to the variety of environmental variables in the chamber. A number of processing companies and designers are working on this problem insofar as their own processes are concerned, but it is a distinct preference on their part to make such investigations of their own processes within their own organizations. Thus, the tempo for application of "systems engineering" is geared to the rate at which the ultimate clients advance this fundamental area of knowledge.

Secrecy surrounding the processes was felt to be a more serious objection in the chemical industry than in the petroleum industry. It is the author's opinion that most processors, if convinced of the worth of a systems analysis, would make details of the process fully known to the systems engineer.

Procedural Difficulties

Current contracting procedures in the process industries also form a barrier to entry of a systems engineering group in the train of contractors. The basic process design may originate either with a processor or with a contractor. In the former case, a contractor is generally selected on the basis of competitive quotations to handle the equipment design necessary to implement the basic process. Consequently, a contractor who provides for a control systems analysis in his quotation will lose out on price. A successful fixed-price contract, with no provision for the systems analysis, does not allow the contractor to engage the services of a systems group for lack of funds. This procedural difficulty can be overcome for processes generated within the contractor's own organization or for cost-plus type contracts. However, this is an added restriction to the possible market. A further reservation is the reluctance of many processors to divide the design responsibility for their plants among several organizations. Orienting a drive for systems work toward the people engaged in design of full-sized plants also runs afoul of the time factor, which might allow three months' maximum for a control system study if it were going to be given effective consideration in purchasing equipment. To do a worthwhile job on a full plant within this time is impossible, unless dependence is placed on rule-of-thumb methods, anomalous technique for a group advocating the rational approach. The author has found this factor tending to orient him toward the research and development units in the processing companies.

Upgraded Processes Coming

Care must be taken not to extrapolate the foregoing remarks to future or more sophisticated processes. As new and more exotic products come from the chemical industry, and more refined products from the petroleum industry, processors are going to higher pressures and temperatures, and more severe conditions in other variables as well. Under these circum-

stances the economic balance will start to swing. Rule-of-thumb excesses in process equipment sizes become more expensive—consider the cost of excess capacity in a 3"-thick alloy steel reactor. Furthermore, computer control in its ultimate application to processing will give the process control system the aspect of the servo system, because the process control system will then be subject to the second restraint, namely, a requirement that it follow a programmed input. However, this must be considered a future development as far as an application of "systems engineering" to the chemical, petroleum or any other allied industry is concerned.

Suggested Current Markets

Not to paint the current picture all black, there are fields in addition to the flow control mentioned earlier in which a systems engineering service finds a receptive audience and also can be justified on rational grounds. The one with the most current promise is the environmental control of aircraft and aircraft engine test chambers and wind tunnels. The operations involve the handling of large quantities of air and the control of its temperature and pressure. The problems, thus, are of a process nature, though the process itself is physical rather than chemical.

The distinguishing feature here which prescribes the use of "systems engineering" in designing the control system is the need to program variations in the environmental variables to follow some arbitrary schedule. Thus, the system is subject to the two restraints that govern a servo system rather than a low-order regulating system: namely, it has a varying input and must resist unprogrammed external disturbances. It has been found that the control thinking of the people in the field matches the need. Control system requirements are spelled out with dynamic specifications, in contrast to the chemical processing field instrumentation language which is couched entirely in terms of static requirements.

Nuclear reactor facilities, whether for power production or research, also appear promising. In this case, though the control requirement is still in the regulator category, the process is such that the cost of additional capacity in and around the reactor is highly expensive, and the excursions which can be tolerated are much more severely limited by the safety factor than in chemical, petroleum or thermal power plants. Also knowledge of reactor dynamics is more generally available.

In certain chemical processes very small excursions from design conditions will cause severe deterioration in yield, or, in some cases, complete breakdown of the process. As a consequence, reaction zone conditions must be very closely controlled and there is no possibility of averaging out variations in product quality, nor do the chemical reaction kinetics permit insertion of capacities to cushion effects of external disturbances. Herein lies an application which is theoretically feasible and economically sound, but is very definitely held back by the lack of knowledge of the process behavior and the shroud of secrecy maintained by individual processors.

Different species of process equipment, rather than the chemical process itself, are worthwhile subsystems for which a specialist control designer can presently make an economic contribution. The components making up much of the equipment are mechanical or electromechanical, both of which are areas well known to the servo-systems designer.

Component Improvement

Throughout much of the author's field work, a number of inquiries were received regarding sensing devices. Regrettably, measurement problems are not in themselves applications of systems engineering and so were not undertaken. Their solution generally requires more specialized knowledge within specific engineering categories, e.g., a chemical process engineer with little control background is better equipped to answer a slurry flow measurement problem than the more generally trained "systems engineer," though the latter may be very well trained in chemical engineering. There is a considerable amount of work to be done at the measuring point of the process variable. Measurement using the established techniques in their present state are not at a level of accuracy and formulation to fit the fabric of computer-directed or rational control system design. A relationship between sensing device output signal and measured variable, which includes a large number of arbitrary constants only valid for a single set of conditions (material, other variables, etc.), obviously is sorely limited in value in a system which must change all variables for optimization. Solutions to the various measuring problems are essential if the over-all system problem is to be handled meaningfully. The instrument manufacturing companies recognize this and are expending a great deal of time and money in this area with marked improvements in certain directions. They are the obvious people to undertake this work, rather than an engineering organization devoted solely to systems design.

Conclusion

This report can only be classed as superficial at this time, but it may be of some use in focusing the eyes of those people with principally a servo background on the present selective needs of process control, which at first glance appears to offer unlimited general application.

Experience Of An Instrument Manufacturer

"The problem of the completely optimized chemical process plant is, at present, a research study which, for various reasons, has blossomed in the literature as an established *fait accompli*" . . . . Not only Americans have been misled by our sensational press.

PERKIN-ELMER, along with most of the other leaders in the field of analytical instrumentation, has been more or less deeply involved in the automation (process optimization) effort in the chemical processing industry. Our program had its inception more than five years ago.

The decision to move in this direction seemed entirely reasonable at the time. Perkin-Elmer's analytical instruments, particularly the infrared spectrometer, originally went primarily to the research laboratory. As the universality of infrared as an analytical technique became more appreciated, and as the instruments themselves became more dependable, they began to find their way into plant control laboratories where they performed valuable service in providing periodic checks on raw materials, process stream composition and product purity.

Although spectrographic techniques greatly speeded routine analysis, the time required for sample collection and preparation, plus instrumental time and calculation, still added up to an hour or more. Every processing engineer is well aware of the number of barrels of sub-standard product that can be produced during such a period! The attractive possibility of "moving the lab to the line" and thereby reducing analytical time from hours to seconds led us to tackle the problem of applying infrared techniques to continuous analysis on the stream itself.

We could already visualize the next step in the chain of development—after the continuous analyzer had proved itself, we could connect it to an environmental controller through a suitable computing link thereby effectively "closing the loop" between the process stream and the environment in which it is produced.

This combination of the physical pieces—tailored sensing system, controller, and special sampling mechanism—together with a thorough knowledge of the process involved, leads inevitably to the "system" concept rather than the provision of specific hardware.

Our present position has permitted us to realize, however painfully, that our financial progress in this endeavor of systems engineering a chemical process via analytical instruments has not been quite up to our expectations and we should like to discuss some of the possible reasons for this.

We feel that the problem of the completely optimized chemical process plant is, at present, a *research study* which, for various reasons, has blossomed in the literature in fashion that gives it the appearance of an established *fait accompli*. It is, in fact, a tremendous research project that has been undertaken by the industrial engineering function, a segment of industrial endeavor that one does not normally associate with basic research.

We do not want to impugn the chemical or process engineer by these statements, as this function is the only one that can undertake the job. We merely want to imply that one normally associates the engineer with the function of reducing to economic practice a process for which the basic research has been pretty well worked over.

Impressions Versus Reality

The wide appearance of process instrument articles in engineering journals, indeed the appearance of new engineering journals completely devoted to the subject, has brought about an impression that complete, optimized process control is an accepted fact, at least in most larger companies. In England, for example, there has been serious consideration of their chemical industry by a government committee, one of whose conclusions was that the British chemical industry was falling behind for lack of a good non-dispersion infrared analyzer. We had conversations with a German chemical engineer who stated that those in the German chemical industry, by reading American journals, had the impression that the United States was making tremendous strides in this area and Germany had to make frantic efforts to catch up.

VAN ZANDT WILLIAMS and **PAUL A. WILKS**
The Perkin-Elmer Corporation

With Systems Engineering

At the conclusion of a tour of American plants, the German chemical engineer expressed relief that the situation was not in accordance with prior reactions—in fact, he felt Germany had more advanced technology.

The situation is that the American chemical industry has been carrying out the published work as *research study efforts* in plants because the study must be made there. (The very fact of publication is, perhaps, a proof of the research aspect—if these were real, proved process economies, publication might not be so immediate.) *but*—they are primarily studies to determine possible efficiencies and economies, and not installations based on proven work. Two years ago, for example, we made a limited investigation of several large companies seeking a small part of a process problem that required a computation involving two output process variables to produce data desirable for automatic control of input variables. We found no such system in existence and only two companies that could point to sufficient dynamic knowledge of a process step that would permit experimentation.

Application Engineering Costs Ignored

Even where the "closed-loop" aspect was not immediately required, there is a major, unexpected problem in the provision of process sensing instruments: the *application engineering* involved in the adjustment of a basic instrument to meet the particular specifications of the problem for which it is to be used. This problem has devolved on the instrument manufacturer because, in general, the buyer cannot maintain such specialized knowledge. We need not dwell on the manifold problems involved here.

So far, particularly where instrument competition exists, the instrument manufacturer has been doing this application engineering at a nominal charge included in the instrument, on the gamble that the same problem will come in from other customers and he will gradually get his money back. This hope has not always been realized and again points to lack of good field knowledge. For instance, one might expect that the isobutane measurement as a measure of debutanizer overhead would be an identical problem throughout the petroleum industry; yet, for reasons of varying raw material or slightly different process criteria, identical problems are not numerous and, in the case of the non-dispersion infrared analyzer, a small change in range of the component to be measured, or the other components to whose variation the signal output should be invariant, often requires an appreciable additional amount of application engineering.

An interesting sidelight on the expense of application engineering has led to attempts to use a single instrument with automatic range variations to measure multiple streams. But a careful study of the advantages and disadvantages of a single instrument for multi-stream analysis shows that such a use may not be economical in the long run. Again, this points to an area where good understanding between supplier and user must be established.

The picture is not so completely discouraging as has been pictured. All our comments add up to this: From our viewpoint, as instrument manufacturers, a combination of the peculiar literature emphasis on automation or optimized process control and the rather easy situation we laboratory instrument manufacturers have had in the recent past (good capital spending, eager research buyers, and a background of academic instrument development) have led us to too rapid an entry into a field which we had not thoroughly studied and with whose difficulties we were not familiar. We've been wounded, but not seriously. A better statement might be that we have paid a high price for some basic experience and knowledge.

We must continue our instrument development, but recognize that it is a development program. We must work more closely in this development with the plant instrument engineer and the plant manager. As suppliers, we must stop trying to buy our competitive way into everyone's front door and we must stop overselling our products. We should try to work only with those sites which understand the basic state of this field and not sell marginal performance to a customer who does not understand the situation.

On the other hand the instrument buyer, the plant manager, must obtain factual knowledge which he does not have—a quantitative figure for the possible economy of continuous sensing devices for indication or direct control. With such knowledge available, and the resultant further experience of the supplier, it will be possible to consider the value of process instruments on a factual rather than a fanciful basis.

The stakes are high for both the instrument manufacturer and the chemical processing industry. Of all industries, the chemical field represents the most attractive return for automation in its truest sense.

SYSTEMS ENGINEERING vs APPLICATIONS ENGINEERING

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MUCH CONCERN has been expressed—and frequently only too painfully truthfully so—about the terminology in systems engineering. We find criticisms ranging from a "lack of vocabulary" to describe what we are doing or attempting to do, to the "super-abundance of useless words" ranging from the strained cognomens of computers to the coining of new words in an attempt to describe and define modified techniques and even vague fields of science.

The stark reality of the situation is that our language is determined by popular and repetitious usage of words. The appropriateness of a word logically determines its acceptance and usage and, ultimately, its inclusion in the dictionary. The definition is nevertheless nothing but a convenient reference point subject to change as usage of and familiarity with the notion changes. There are many examples to prove the point that, no matter how desirable a definition may be, it is impossible to force a word upon people and expect them to use it against their collective will. And doesn't this, as a desirable and true expression of a dynamic and democratic process, ultimately produce the most flexible and expressive language?

Words and terms such as "Systems Engineering" and "Applications Engineering" are meaningful only when the concepts have been accepted, not by so-called experts in the field who lay claim to have defined the concept or approach, but by the multitudinous array of engineers, administrators, technicians, and associated souls who are faced with the very real problem of communicating notions to and amongst one another in a succinct and picturesque manner.

For instance, we find etymological forces introducing the word "Automation" into our language in a manner similar to those which, at an earlier stage, introduced notions such as "Mechanization" and "Mass Production."

In a very general sense, it can be stated that "Applications Engineering" pertains to the notions and techniques associated with suitably installing an existing product into a unit in which it is to function. It is to be noted that by this definition no mention is made about the adequacy of the host unit in a large assembly or equipment.

Systems engineering, on the other hand, implies an approach dedicated to a careful consideration of *all* aspects of design, manufacture, and ultimate use, including the host equipment. It presupposes the ability on the part of the Systems Engineer to evaluate an assemblage of objects, or equipment, united by some well-defined interdependence of action, and so combined as to form an integral whole to function in unison and in obedience to some form of control. This signifies a broad concept and has the definite implication of single responsibility for large groups of instrumentation.

It is quite realistic to state that the successful Systems Engineer has demonstrated a profound knowledge of dynamic and process analyses, specialized aspects of physics and chemistry, and specific scientific disciplines required to formulate the application of instrumentation. All of these impressive requirements notwithstanding, the Systems Engineer is not afraid to recognize his need to consult specialists in highly

"Systems Engineering can flourish only in an atmosphere of complete independence of approach, unfettered by encumbrances of hardware . . ."

technical phases as, for instance, computer logic. Indeed, so well understood is this problem in organizations seriously dedicated to systems engineering, that permanent consultants are retained at various levels of engineering to contribute expert assistance exceeding the capabilities of any single individual. And it is just such peripheral services as these that not only justify the systems engineering approach but establish the wherewithal to supervise the physical realization of the optimum system to perform an assigned complex task.

In the purest sense, Systems Engineering must be wholly objective. It can flourish only in an atmosphere of complete independence of approach, unfettered by any encumbrances of hardware, sales quotas, or company predilection for particular pieces of proprietary equipment. Hence, an enterprise that desires to enter the systems engineering field must establish an organization which is spiritually, and preferably geographically, isolated from any operating executive concerned with production or sale of specific general-purpose, or consumer, products.

By the same token, when necessary, the systems engineering group must be able to design and construct hardware prototypes fully compatible with the best equipment manufacturing techniques, yet eminently suitable for the requirements in the system under design.

Ideally, once such hardware has been produced, arrangements should be made for manufacture *beyond the confines of the systems group.* If necessary, production should be assigned to a separate organization which has already demonstrated its capabilities efficiently to mass-produce such items.

The Systems Engineering group itself, which usually accepts responsibility for performance, must be comprised of a close-knit team of specialists encompassing all engineering disciplines from civil through mechanical and electronics. Since the scope of problems ranges from design concept through the assembly of prototypes, including the design of special equipment, a product is almost invariably involved. And, as we become better and better equipped by experience more clearly to define those forces which determine the concept of over-all systems responsibility we notice that, in contrast to the classical concept of engineering consultation, in the systems concept functional hardware can be the end-product.

The cost of this hardware represents not only the price of materials and standard components, but must of necessity reflect the engineering required for the integration of such components into a single-purpose whole, as well as the responsibility assumed for the obedient behavior of the equipment in the completed system. Here again is an example of the demarcation existing between "Applications Engineering" and "Systems Engineering"—the justification in the latter case to charge for additional services predicated by *assuming responsibility* for "on stream" performance of the equipment.

This all-important phase of Systems Engineering is a practical necessity since it is an inseparable and distinctive feature of the very concept that hardware be designed and tailored for a specific system—hardware for which there can usually not be found widespread application as general-purpose units. The reference here is to special equipment, for very seldom are items such as voltmeters or oscillators designed especially for a system unless, of course, the specifications for them are unique and distinct.

The cost factor notwithstanding, the concept of Systems Engineering is justified and profitable for industrial as well as for military applications. However, it is not, nor can it ever be, a "give-away" since it implies an independent and unique approach to the solution of a specific problem, including *full responsibility for the effective functioning of large groups of instrumentation,* perhaps from many manufacturers.

And as this extended notion gains recognition and becomes accepted as the logical solution to increasingly complex process analyses and control, the concept of "Systems Engineering" cannot help but assume meaningful generic significance in our vocabulary along with such concepts as "electronics," "mechanization," and "industrialization."

"With only rare exceptions, however, regardless of title, the man who specifies the control system is the organization's instrument specialist. He is the man with both process and control experience."

Who Specifies

A QUESTION frequently asked is, "Who is primarily responsible for the selection and specification of engineered control systems?"

To answer this question let us first define the term *engineered control system*. A control system is a combination of control devices applied to a process unit—one open hearth, one distillation column, etc. To state that the system is engineered implies that the control devices are integrated with each other and with the process equipment by the application of engineering principles.

The question, "Who specifies systems?" can be restated as "What is the position or title of the man who designs and specifies the control hardware?"

In the contract engineering field his title may be Instrument Engineer, Project Engineer, or perhaps Process Engineer. Among users' design-engineering groups he may be called by similar titles.

Many control systems are specified and procured at the plant level. As any instrument salesman can tell you, here the titles also are multitudinous. The specification writer may be found in any of the following groups:

Management—President
Plant Manager, etc.
Operations—Superintendent
Process Engineer
Supervisor, etc.
Engineering—Chief Engineer
Instrument Department Head
Instrument Engineer
Chemical Engineer, etc.
Maintenance—Plant Engineer
Maintenance Superintendent
Instrument Supervisor, etc.

Exactly which of these men specifies the equipment depends entirely on the plant. At one large well-known process plant the Foreman of the Instrument Department specifies every piece of control equipment in the plant. In smaller plants it may be the President himself.

In some instances a preliminary system design is worked out by the joint efforts of a combination of instrument specialists representing the user, the contracting engineer, and the instrument manufacturer's application engineer. Each contributes his own specialized knowledge to the solution. The user may have detailed information and experience with the particular materials or process. The design engineer has broad experience in similar and related applications along with an intimate knowledge of costs. The manufacturer's engineer is familiar with certain components, and their unique performance characteristics and maintenance requirements.

A control system depends for its success not only on the instrument equipment used but on many other factors—the process equipment, the interconnecting piping or ducting, the chemical and physical dynamics of the process, and above all a definition of the precise results desired. Therefore, it is common for controlled systems to be engineered as somewhat of a team effort. The talents of the process and equipment designers are pooled with those of the specialist in measurement and control.

In research organizations one may encounter instances where physicists, chemists, or other non-engineering personnel specify control systems. We are told that there is actually one research organization where this duty falls to a secretary!

With only rare exceptions, however, regardless of title, the man who specifies the control system is the organization's *instrument specialist*. He is the man with both process and control experience.

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"There has been no revolutionary change from plant instrumentation to engineered control systems. The two terms are synonymous . . ."

Control Systems?

Observation leads to two significant conclusions: First, there has been no revolutionary change from "plant instrumentation" to "engineered control systems" other than a change of terminology. These two terms are synonymous in 99 out of 100 actual plant situations, in practical effect and in end result.

Second, to our knowledge, there are few "Control Engineers" with that title in industry. This title, while seeming to suggest the exhaustive application of esoteric control analysis techniques, overlooks both the *measurement* and *empirical* aspect of plant design.

Another question that is commonly asked is, "Why is it that recent developments in control technology have not revolutionized the approach to the procurement of control components?" The answer is that recent technological advances have merely added to the tools of the instrument specialist. They have not created a new science, but merely extended an old one. The recent developments are causing evolutionary, not revolutionary, progress.

In industry, particularly the process industries, the amount of scientific armament brought to bear on a control problem is a simple matter of economics. Engineered systems inevitably involve compromises all along the line. The technologist must analyze the problem and select his weapons in a manner to achieve the most economical results. In the final analysis there is no substitute for good judgment *based on broad experience* to achieve maximum results at minimum cost.

A typical application may present these problems: Can ten thousand dollars be shaved from the cost of a chemical reactor by reducing its size and adding about two thousand dollars' worth of instruments? How much will the cost of maintenance or operation rise? How is availability of equipment affected, and how much is this worth? How will any possible savings balance out against the estimated cost of additional engineering analysis?

Each specific process control problem must be evaluated individually. Can the design be based on past experience with the same or similar processes? What are the probabilities of gain if more engineering time is invested in an attempt at improvement? Can the dynamics of the process be determined with sufficient reliability? Is simulation, computer study, or pilot plant development warranted? If so, to what extent is a study justified by a promise of return on investment? Such questions are not new to the instrument field; indeed, they have always been the basic problems facing the plant constructor and the instrument engineer.

An entire plant contains an aggregation of unit processes more or less interrelated. From a practical standpoint, then, it is not necessarily desirable to design a plant which is one beautiful conglomeration of engineered control systems representing harmonious perfection. It is more important that the completed plant be a production unit which demonstrates optimum performance from an overall *economic* standpoint—that it can produce what it was designed to produce at minimum cost, within given and finite limits of both time and money.

In industry, expenditures of either time or money above minimum design criteria are frowned upon, and it has been found that only experience permits an engineer to balance design criteria against the operating vagaries that plague all processes. Such experience does not come with a title, even that of Control Engineer, but only with years of experience in instrumentation and process work. No substitute has been found for this type of experience.

Table 1—OUTLINE OF COMPUTER APPLICATIONS IN THE PROCESS INDUSTRIES

I. Plant Design Studies
  A. Trial and Error Calculations
  B. Process Data Evaluation
II. Plant Operations
  A. Operations Research or Linear Programming
III. Process Control
  A. Evaluation of Spectrometer Data
  B. Process Simulation
  C. Plant Process Control Direction

Computers in the

Perspective on the present and future role of computers in the process industries is best obtained by a résumé of the applications to date, including the difficulties thus uncovered.

CHEMICAL INDUSTRIES have not made as much use of computers as have the aircraft industries, but such use is increasing. The bottleneck and challenge lies in thorough understanding of the kinetics and dynamics of the process or plant operations. Reasonable progress here will require a combination of all pertinent theoretical and empirical information that can possibly be secured or estimated from plant operation and basic laboratory data. A very high degree of collaboration and understanding will need to be reached between computer specialists and plant engineers. The latter may well be the bottleneck unless they can be provided with the background necessary to participate in the cooperative venture.

All of the largest process companies have formed machine computing organizations, and many of the smaller companies are likewise equipped. Let us first discuss some of the applications which these companies already have made of computers and also some possible future applications. Table 1 is an outline of these applications.

Plant Design Studies

A combination of the trial-and-error empirical design methods and the use of the small accounting type machines such as the IBM 602A and 604 led to the first major use of computers in the chemical industries. This was in the design of distillation columns.

Distillation columns are among the most used pieces of equipment in the petroleum refinery and chemical plant, yet their accurate design is one of the most complex and tedious duties now facing the chemical engineer. Distillation calculations have thus been the subject of a very large number of short-cut and approximation design formulas[37]. However, none of these have proven entirely satisfactory, so the machine computation of the tedious trial and error computing method has been extremely welcome to the engineer faced with this task.

The complete design of a distillation column includes the determination of the distillate and bottom compositions and the number of plates required for a whole series of different reflux ratios in order to pick the proper combination to give the most economical column as regards both initial investment and also operating costs. The trial-and-error computation for only one reflux ratio could take up to a week of hand computation in complex cases; thus the number of trials carried out was always small with this method and, therefore, the best choice was often not available to the engineer when making his final selection.

The IBM 602A and 604 Punched Card Calculators could carry out plate-to-plate calculations of some equations. The advent of machines like the Datatron and IBM 650 have permitted the selection and evaluation of a whole range of reflux ratios automatically, and even larger machines can make the whole process automatic.

The *design* of equipment such as absorption columns[13, 19], ion exchange columns [33], fluid flow systems[25, 36], heat exchangers[21, 35], and many other such items is also carried out using trial-and-error schemes much like that for distillation columns. Again the saving is tremendous. Details of the procedure used in each case can be obtained by consulting some of the references listed.

Process Data Evaluation

Process data evaluation is one of the two major areas in the chemical industry where electronic data processing can play a major role in the future development of chemical engineering. A large mass of data is continually being gathered in the industry on such factors as the composition of the vapor being given off by a boiling liquid mixture, or on the amount of heat being transferred across a boundary of a certain material, or on the rate at which a certain chemical

An abstract of an article (with additional comments) entitled "Computations in the Field of Engineering Chemistry," by Theodore J. Williams, R. Curtis Johnson, and Arthur Rose, in the October, 1957 issue (Vol. 4 No. 4) of the *Journal of the Association for Computing Machinery*, with permission of the ACM.

Process Industries

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reaction proceeds with different initial ratios of constituents and different external conditions. This type of data must be correlated into sets of equations relating the important variables in their proper order if it is to be useful in plant design and operation studies.

For example, the successful pursuit of a distillation design procedure depends almost entirely on the availability and accuracy of the vapor-liquid equilibrium relation[7]. Prior to the advent of computing machines the most popular form of this equation was the extremely simple one

$$y_i = K_i x_i$$

where K could have widely different values depending on the mixture, the individual component and the temperature. Extensive tables and charts of these values were therefore published and widely used[19, 44, 46].

However, this simple relation even in table form could be used with accuracy only with hydrocarbon mixtures or other ideal solutions. The representation of non-ideal mixtures usually required the use of the concept of an activity coefficient and a complicated analytical expression. In addition, the use of computers also requires that we have analytic expression of the plate-action equation for all conditions to be encountered in any one problem, instead of a set of tables as before. The resulting expression can thus become very complex.

The correlation of the experimental data necessary in order to evaluate the very great number of constants in any particular equation is, therefore, a very desirable application for digital computers[9]. It usually involves the solution of a large number of simultaneous algebraic equations, a task for which these machines are well suited, particularly as their capacity increases.

A complexity similar to that for the general equations of vapor-liquid equilibria is involved in calculating the mass-transfer coefficients needed for designing absorption and extraction columns, and for the heat-transfer equations needed for the design of all types of heat exchangers as well as other related design studies.

As another example of great importance to chemistry, let us consider the chemical engineer's study of a chemical reaction. He is interested in having the reaction go as far as possible toward completion, and at a rapid but controllable rate. The rate of appearance of a product or of the disappearance of any reactant during a chemical reaction is specified by a single rate equation. However, most reactions involve two or more reaction steps going on simultaneously, and the presence of catalysts and sometimes of impurities will alter the relative speed of these steps so the exponents usually turn out to be fractional and must be evaluated from experimental data. Here again the data-processing type of computer operation is vitally needed.

Another related problem is the computation of the composition of a reaction system, that is, the identity and amount of the various components, once final chemical equilibrium has been attained. This calculation usually involves the solution of a group of simultaneous algebraic equations and is well adapted to solution by a digital computer. It was therefore one of the first problems tried and is still one of the most widely solved[8, 29, 50].

Plant Operations

Operations Research—Linear Programming. In addition to the analysis of the operation of individual plant units to determine their optimum operating levels, the chemical and petroleum companies are vitally interested in being able to carry out computer analyses of the operation of whole plants or the entire company if need be, perhaps to discover best operating levels and methods. Therefore, they are vitally interested in the latest developments in the field of operations research, or linear programming as it is sometimes called. In fact, many of them are already working on the next advance in this field, nonlinear programming.

Only the larger companies are equipped with large-scale computers at present so the majority of the activities in the field to date have generally been on a small scale. Also, due to the extreme proprietary nature of the material covered, little of it has been published. However, one symposium[12] and several papers have appeared[1, 47, 48] and other symposia are scheduled for the near future.

Process Control

Evaluation of Spectrometer Data. Control engineers in the chemical industry have found that exact control of a process is possible only when the actual composition of the various plant streams are the variables sampled,[45] perhaps through the use of an absorption spectrometer.

A typical chemical plant can require the analysis of several hundreds or thousands of samples of up to 10 components each per day while under automatic control; the evaluation of these data becomes a tremendous task without computers.

The first attempts to solve these equations by machine were carried out on analog computers of the

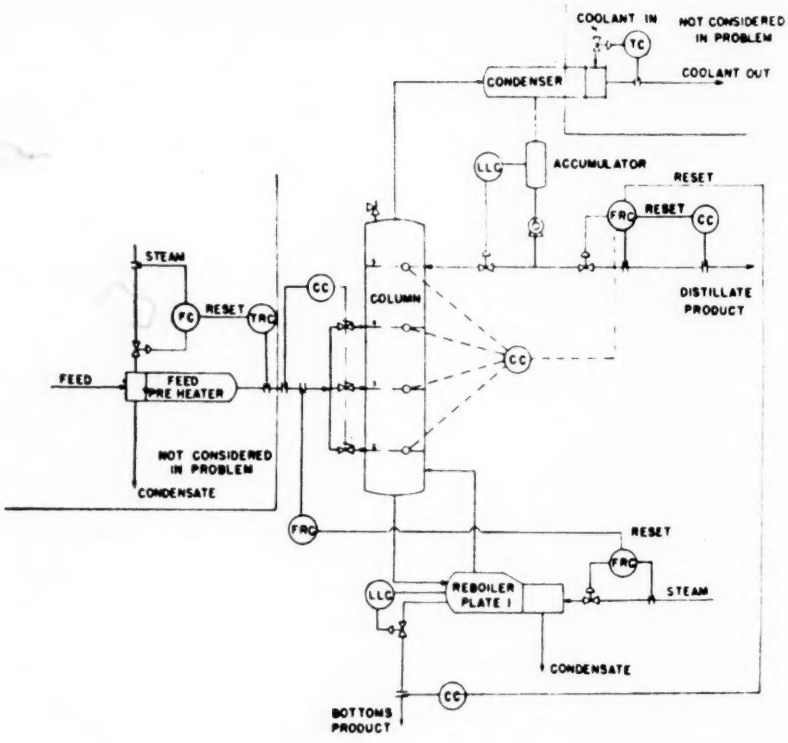

FIG. 1. CONTROL SYSTEM for a distillation column.

network-analyzer type which solved the equations by a trial-and-error, null-balancing method[21]. However, for ten components this also can become quite tedious. Next, accounting-type digital machines[4] and the IBM Card Programmed Electronic Calculator[26] were adapted to this work. Recently the medium-sized digital machines such as the Datatron and IBM 650 have been used extensively. One company recently procured a Datatron for scientific calculations, but the analytic people so swamped the machine with spectrometer analyses that the company has been forced to procure still another machine for its previously contemplated scientific calculations.

It is also common practice now to see *mass-spectrometer* data fed through an analog-to-digital converter and then into an automatic key-punch device and electric typewriter. When all the samples have been run, the program is loaded into a computer, and the data cards placed in the hopper. Even with the medium-size digital machines, the inverse matrix operation usually proceeds at a rate of one sample calculated every 15 to 20 seconds. The sizes of the matrices vary from about 8 x 8 to 24 x 24 and higher.

In order to be useful for plant control, spectrometer data must be evaluated immediately after it is obtained. Therefore, it is necessary that a computer be available for this task whenever needed. This computer would thus be either unavailable for other tasks or, at best, highly restricted in its use. This calculation is ridiculously easy for the modern medium or large-sized computer since it has far more storage capacity and flexibility than needed here. Therefore, it appears that there is a very definite field for a digital computer with (a) high computation speed to handle several spectrometers on a time-sharing basis, (b) small storage—sufficient only to handle the problem at hand, and (c) fixed program specifically designed and permanently wired only for this computation.

Such a computer should be quite inexpensive compared to the machines now used for this problem and would free them of tasks to which their larger capacity is more suited.

Process Simulation

The chemical and petroleum companies are also increasing their investigations in the field of automatic process control. This increased interest is due to the same cause as that previously mentioned for automatic computing itself—the economic desire to design, build, and operate their plants so as to show the greatest margin of profits—especially when faced with the possibility of a leveling national economy.

Before we can apply optimated automatic process control to individual plant units, let alone complete plants, however, we must know the dynamics of these plant units, and we must be able to pick the best possible type of control for these units. (The present state-of-the-art in this field was brought out in the "Symposium on Transient Process Behavior and Control" recently published[22].) This information can be developed in either of two ways. The first is through

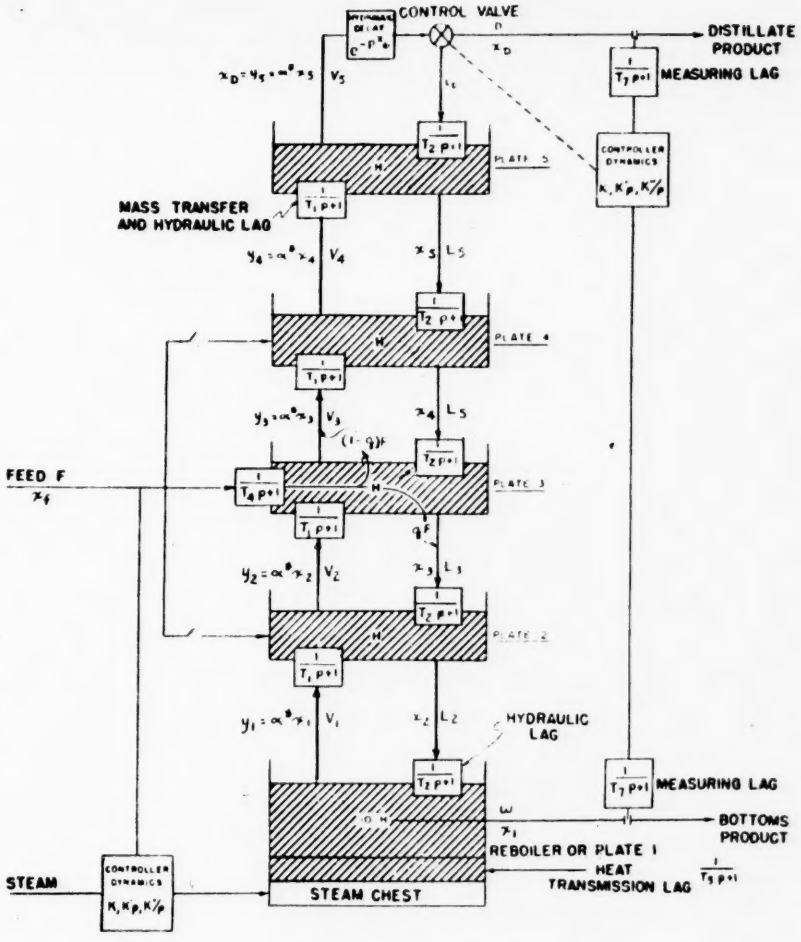

FIG. 2. DYNAMIC RELATIONS in 5-plate model of distillation column.

experiments on actual plant-type equipment, but possibly of a smaller size. The second is through simulation of the responses of the actual equipment on electronic computers. Interests of economy, speed and breadth of data possible all point to the use of computer simulation for the great mass of this work whenever possible, with an allowance for verification tests of selective items of the data on actual equipment. The latter is to prove the validity of the mathematical model being used. However, calculations of this sort for chemical engineering operations of practical interest are fantastically complex.

As a possible example of this let us consider the work on distillation column simulation which was recently reported[2].

Figs. 1 and 2 show a schematic diagram of the simulated column. This column has only five plates in contrast to up to a hundred in an actual tower. In addition, it is separating a mixture of only two components, while the feed to a commercial column usually contains many components. Nevertheless, the simulation of even this small example required an analog computer with 34 amplifiers, 16 servos, and an ample supply of other auxiliary equipment.

It is hoped that the proper choice of a simplified mathematical model will answer questions which might be asked of the more complex model. This, or the development of computer routines to more adequately handle large and complex systems, appears to be our only salvation.

The same holds true for the computation of the control response of a heat exchanger or almost any other possible type of equipment. For example, the heat exchanger simulation papers in the symposium mentioned were all for the case of a simple countercurrent concentric-pipe exchanger, whereas most actual commercial exchangers are of much more complex form.

There is, therefore, the chance for a great contribution by computer-trained people either in developing simplified yet accurate mathematical models of these processes, or in developing new computer routines which can economically solve the equations for systems of practical size.

Plant Process Control Direction

A combination of the linear-programming or operations-research activities with the process simulation and spectrometer analysis computation may *eventually* lead to the use of computers in the chemical industry for completely automatic plant control.

Of course, this is primarily *speculation*. While these possibilities have been mentioned by many authors, and while the first digital computer purchase for control of a polymerization unit has been announced by Texaco's Port Arthur, Texas, refinery, no direct steps have been taken as yet to implement such an over-all control plan in the industry. *The vast majority of the data needed to carry out such a program is not available at the present time.* On the other hand, many of the companies are hard at work developing such data for the purpose of ultimately facilitating such a system should it appear financially sound when the time comes that it is operationally feasible. For example, a data logger at a new Esso catalytic cracker (Belot, Cuba) will, in the near future, log eleven "operating guides," such as the reactor's superficial velocity. Much data of this type will be required before computer-control becomes general practice.

Some Suggestions to the Chemical Industry to Further the Use of Computers

There are several courses of action open to the chemical companies which can help to further the use of computers in their organizations and eventually aid their own economic position.

Every new computing group which is formed in the chemical industry must go through essentially the same growing pains as did those which preceded it. The waste of manpower involved in this duplication is tremendous and it is regrettable in view of the present critical shortage of computer-trained personnel in the chemical industries. Perhaps more chemical and petroleum companies could be encouraged to enter into machine computing if a more open forum could be held on computers and computing within the industry.

Some ways in which this might be done are as follows:

1. Establish a free exchange of completed computer flow charts between individual companies or encourage the establishment of an industry-wide program "bank" similar to that already used by many of the educational institutions and computer manufacturers. If the companies can be made to realize that they have much more to gain from such a cooperative arrangement in manpower savings and in computing progress than they might possibly lose in economic advantage, the "secrecy" problem can be handled.

2. The chemical companies, both those contemplating entering the computing field as well as those already engaged but thinking of expanding their operations, vitally need straight answers to such problems as:

(a) What is the best size of computer to procure for a company of given size?

(b) What are some specific examples in dollars and cents of savings which have been made in design costs, plant operating expenses, or in original plant investment which can be attributed to computers?

(c) Just what are the advantages of buying a computer versus renting as regards economy, obsolescence, facilities expansion, etc?

(d) In the field of large-scale computers, what if any penalty is involved in procuring a business-type data-processing machine versus a scientific data-processing machine in order to secure the help of the accounting department in justification for the machine?

The answers to these and many other similar questions already exist in the industry, but some type of collaboration needs to be developed to get the information coordinated and presented.

The shortage of qualified computer people in the chemical industry was previously mentioned as a bottleneck in computer application. The industry itself can help the universities correct this by providing financial assistance to universities for procurement of computing equipment.

The chemical engineering curriculum is already full, thus the introduction of courses in advanced mathematics and computer application can be made only at the expense of something else.

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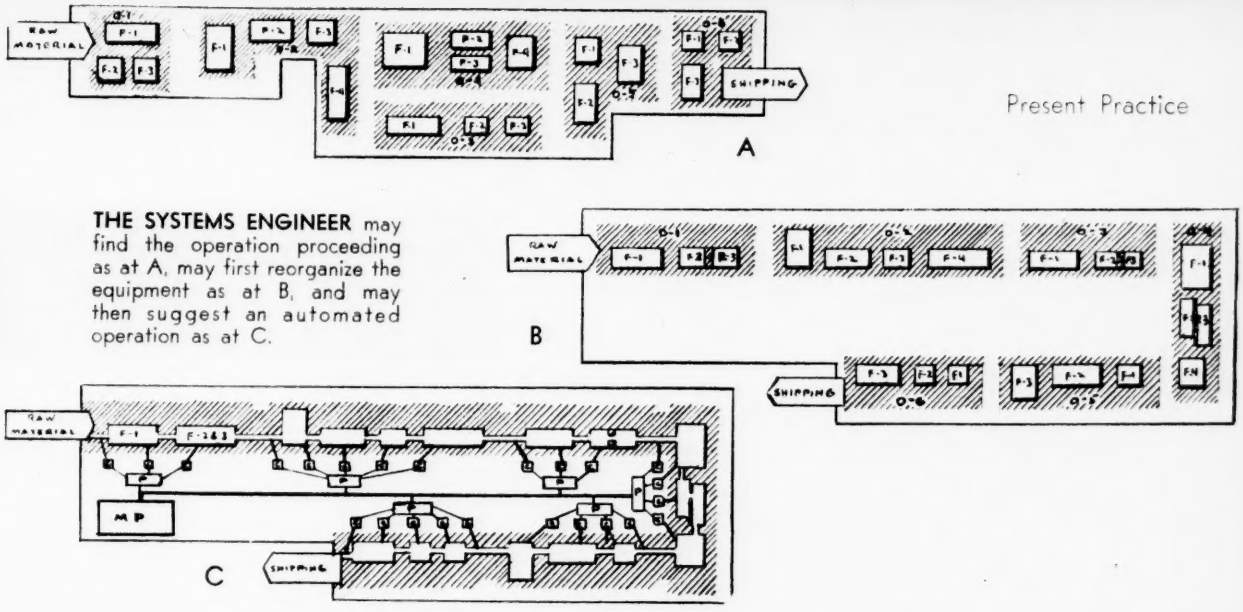
Note: First number (in italics) in each reference is volume number.



Present Practice

THE SYSTEMS ENGINEER may find the operation proceeding as at A, may first reorganize the equipment as at B, and may then suggest an automated operation as at C.

Economics of Systems Engineering

The systems engineer must assume the responsibility for economic analysis of alternative and possible future production possibilities, and the responsibility can extend from cost of land to cost of maintenance.

D. D. MacPHERSON
Patterson-Emerson-Comstock

SYSTEMS ENGINEERING is the study and planning applied to the *development* of a system of production. The goal has become constant, automatic flow of material from operation to operation, from raw material to finished product, with each operation integrated into the system in optimum manner.

Responsibility of the Systems Engineer

The systems engineer has the responsibility for planning and constructing not only an operating plant, but one ready for future production possibilities. This applies to improvements in existing plants and to construction of new facilities.

At all times the systems engineer must compromise two factors—technical possibilities with economic justification. His job begins with a preliminary survey of the problem, including analysis and motion studies of each operation. Next come recommendations for possible paths of flow and possible production techniques, including alternative procedures, availability of machinery and equipments to meet the needs, and necessity for prototype developments on needed but unavailable equipments. The full report might include some or all of the following considerations:

1. Recommendations and cost estimates for location and purchase of new land.
2. Recommendations and cost estimates for constructing the plant.
3. Recommendation and cost estimates for procuring available processing equipments.
4. Recommendations and cost estimates for devising needed prototype equipments not available commercially.
5. Recommendations and cost estimates for installing the system.
6. Recommendations and cost estimates for servicing the system.
7. Recommendations and cost estimates associated with the raw material supply.
8. Recommendations and cost estimates associated with the labor supply.
9. Recommendations and cost estimates associated with the marketing conditions.
10. Personnel and skill requirements for plant operation and maintenance.
11. Effect of transition on current production.

These and many other considerations will arise for decision during this important phase of plant design or improvement. The report on recommendations prepared by the Systems Engineering firm must take most of these factors into consideration, and consultation between the systems firm, plant management, and equipment suppliers, including instrument suppliers, is then used in arriving at decisions.

Role of The Systems Engineering Firm In Prototype and Consultation Work

"The problem of satisfying the demands of industry for automatic operations is one that is not clearly defined at present. On one side we have the instrument manufacturer —on the other we have the systems firm without a line of general-purpose hardware. The systems firms learned early to differentiate between customer desire and customer need."

JOHN BYLO
Industrial Electronic Engineers

DEVELOPMENT of a complete system to perform a series of operations automatically in an industrial concern requires a high degree of coordination with all departments concerned to assure compatability with the present operations, and to accurately and completely determine all requirements of operation. To do this it is often necessary to conduct a considerable amount of basic research in both the electronic and mechanical fields, resulting in many special types of equipment in order to meet the specifications and requirements of that particular business—especially where there are no commercial components available. The average problem involves either (1) the adaptation and modification of existing commercially-available equipment or (2) the development of entirely new "hardware," as shown by the following examples:

Typical Systems Jobs

Fig. 1 shows a typical system developed for an avocado fruit processing plant.

The Problem: (1) To automatically weigh and remotely record the net weight and growers code identification on a special work sheet. (2) To eliminate the human factor in material handling and in the recording of weight information. (3) To meet specifications and regulations of the states' Bureau of Weights and Measures.

Equipment Available at the time: Fruit box handling machines; Conventional power conveyors; Box dumping device; Commercial dial scale.

To the existing equipment was added a specially designed electronic instrument for "reading" the dial scale and recording accumulated weights on demand, with an electronic system (also specially designed) for controlling related materials-handling equipment in the over-all operation. None of the devices or electronic controls were commercially available.

Shipping Labels With Memory

Fig. 2 shows an I.B.M. 407 unit that is used to print shipping labels consisting of customer address, contents of package, and load and stop numbers for loading direction.

The Problem: To overprint on the shipping label, in large open-face type, the load and stop numbers without obliterating information already printed on the label.

Equipment Available at the time: I.B.M. 407 accounting machine.

Added was an auxiliary printing device with the large numerals, mounted on the I.B.M. unit, with controls and memory unit in a cabinet shown at left of the 407. The larger numerals were printed at a station five cycles later than the actual printing of the label by the I.B.M. machine, so a memory storage unit was designed to store this information for five cycles prior to printing the larger numerals. The problem also required a "printer" to print larger numerals on the shipping label, but a special memory storage and electronic controls were necessary to complete the over-all operating unit.

An Automatic Warehouse

Fig. 3 shows a large machine and electronic control system for automatically "picking" and assembling customer orders in a wholesale drug warehouse, controlled by the same punched cards that were used to invoice the customer order.

The Problem: To automatically select, dispense, and assemble (by orders) packaged drug items, at a speed of 2000 average orders per 8 hour day, from a selection of 1300 items.

Equipment Available: This problem required new and original concept of material handling and data process controls.

The following represent the basic equipment components required for an over-all system:

A. I.B.M. (modified) card reader.

B. Special-purpose computer to program item selection.

C. Magnetic data storage drum for item identification and item quantity requirements.

D. Electronic control system for dispensing-transporting and assembling of orders.

E. Mechanical storage racks, dispenser racks, dispensing devices, etc. Special related conveying equipment and order packing stations.

The control equipment consists of a special purpose magnetic drum, a digital computer, a relay switching system, and an I.B.M. machine for input information. Operation of the machine is entirely automatic. One operator is used to feed "decks" of cards to the tabulating machine hopper. The decks generally consist of 20 or 30 orders and the machine automatically turns out one order after another with no intervention or attention by the operator.

The Instrument Manufacturer Vs the Systems Firm

As has been shown, the average systems job to date has been a custom job that existing instruments or standard components could not perform.

The problem of satisfying the demands of industry for automatic operations is one that is not clearly defined at present. On one side we have the instrument or component manufacturer who builds equipment to fill a specific need; his problems include the sales and marketing of these instruments. On the other side we have the systems firm without lines of general-purpose hardware. Both are attempting to satisfy industry's requirements for automation. Instrument manufacturers, and especially those engaged in the sales and marketing of instrument and components, are only gradually realizing the importance and high costs of properly evaluating a customers *need*, and some have had sad experiences when attention was focused on sale rather than customer need in a systems approach.

The systems engineering firms came into existence to fulfill customers desire and need for total automation, and learned early to differentiate between the need and the desire. It is not uncommon for the customer to desire total system automation, packaged and ready for use, but it is often disastrous to attempt to fulfill that desire without a proper evaluation of the need.

The systems engineer recognizes that the many pieces of available hardware and components and instruments serve the purpose for which they were designed; in fact, he depends upon that supply of equipment and components for the systems he designs. But the day has not yet arrived when complete automation can be achieved by simply assembling standard packages of instruments and controls. Today each systems job requires much preliminary analysis of the problem, intensive survey of the customer's problems and products, and detailed analysis of alternative approaches even before prototype equipments can be designed or available equipment modified for the systems task at hand.

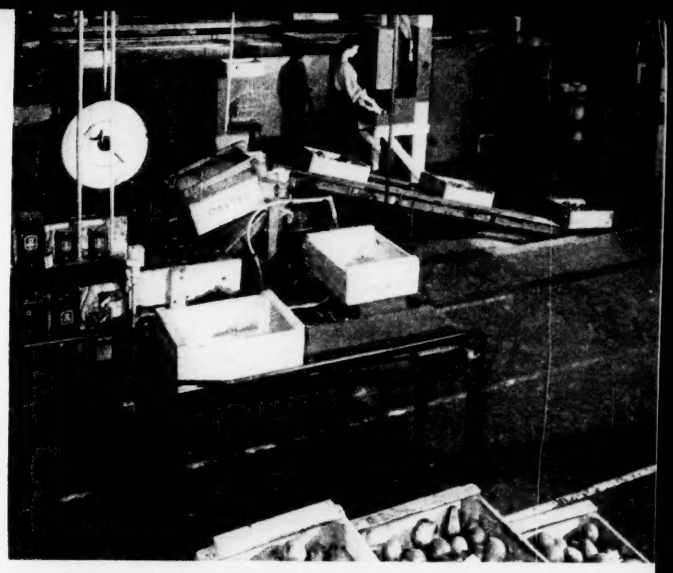


FIG. 1. THIS "SYSTEM" for weighing and handling fruits required the development of a special instrument for reading the dial of a commercial scale plus an electronically controlled materials-handling programmer. Girl in center of picture is at print-out mechanism.

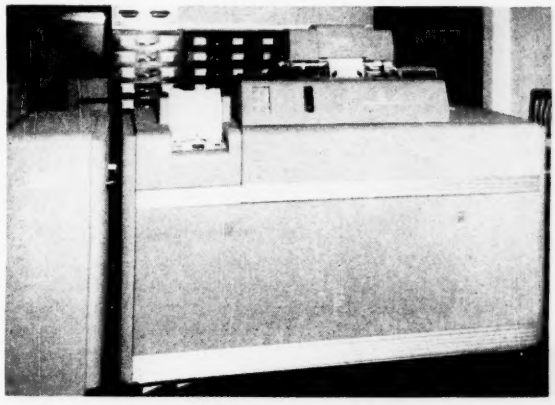


FIG. 2. THIS PROBLEM required a special-purpose printer and a special memory storage unit.

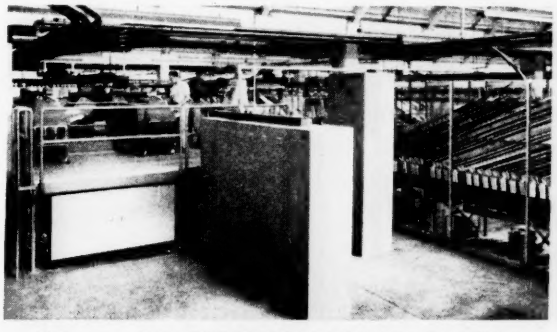


FIG. 3. COMPUTER-CONTROLLED SYSTEM for filling warehouse orders at rate of 2000 orders per day, from a source of 1800 items.

Load and Frequency Control Shows Role

J. W. HOAG
G. W. McKNIGHT

Minneapolis-Honeywell Regulator Co.

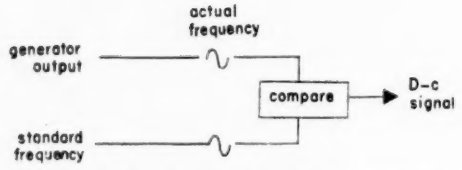


FIG. 1. FREQUENCY DEVIATION is obtained by comparing actual frequency to standard frequency. Proportional d-c signal represents any error. Adjustment is included so that system can be set to pick up, or lose, a fraction of a cycle each second.

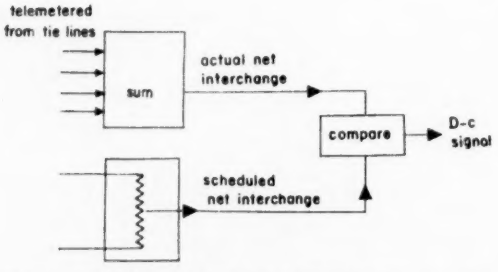


FIG. 2. TIE-LINE (LOAD) DEVIATION data are obtained by comparing actual net interchange to scheduled net interchange. Resulting d-c signal represents error.

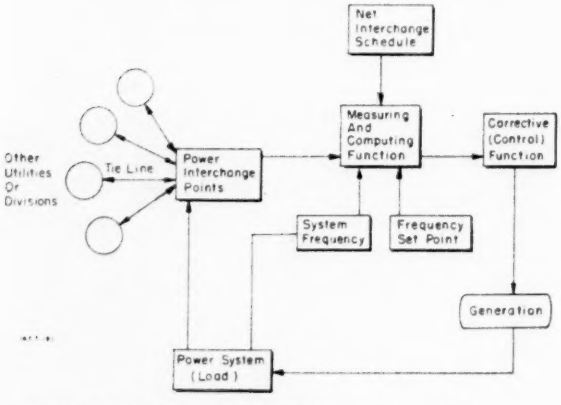


FIG. 3. MAJOR FUNCTIONS of the control system. Frequency and load deviations are basic input variables. These are combined to produce a single command signal to a control servo.

NIAGARA MOHAWK Power Corporation supplies electric service to more than 1,038,000 customers in a 36-county, 22,000-square-mile area in western New York state. Its domain runs from northern boundaries in the St. Lawrence River region to the Catskill Mountain foothills in the southeast and the Pennsylvania border on the southwest. The network includes more than 100,000 miles of transmission, distribution, and feeder lines.

Three division—western, central and eastern—comprise the Niagara Mohawk system with headquarters, respectively, in Buffalo, Syracuse and Albany.

Western Division

The Western Division's new automatic load and frequency control system is located in downtown Buffalo. It regulates eight steam generating units. The six at the Charles R. Huntley steam station in Tonawanda total 540 megawatts; the Dunkirk steam station on Lake Erie has two units with a total capacity of 200 megawatts.

Design Criteria

Before embarking on any program of equipment development it is important to establish *design criteria*. Such design criteria must be based upon the idiosyncrasies and operating experience of the particular industry in which the instrumentation will be used.

Load and frequency control systems for central power stations have occupied the attention of Honeywell for years. The Honeywell philosophy from the time investigations of load control began some 10 years ago was that any such system should provide "fringe" (proportional) plus "sustained" (reset) control. This has been a common and widely-accepted type of control for years in other processes such as chemical plants and refineries.

of the Instrument Manufacturer in Systems Engineering

This load and frequency control-system report illustrates how the instrument manufacturer performs Systems Engineering by combining shelf hardware with redesigned units and new prototype components.

Function

The responsibility assumed by a utility is the task of generating and distributing as much electric power as its customers demand, and delivering this power at a frequency of 60 cps. Thus the basic variables to be controlled are *load* and *frequency*.

To do this, utilities first compare their output frequency with a reference frequency. In this system, slide-wire "compare" circuits develop a positive or negative d-c output depending on whether the system frequency is high or low (Fig. 1). If actual frequency is low, the signal calls for more steam to the turbines to pick up speed.

Most major electrical power systems are interconnected with at least one other system so that each can help the other. Such cooperative action permits the utilities to rely on emergency generation from its neighbor, and, at times, may allow one utility to supply load in excess of its own capacity. It also allows economies to be effected by both utilities by using the most economical generation of both to supply their loads. However, with the use of tie lines, better control of generation is essential.

The generating systems are tied together via tie lines, and the companies agree to a scheduled tie-line interchange (say, 50 megawatts). The signal at the tie line is used as the basic input to the control system.

When setting generator output a utility need not identify the shifting load demands of its customers within its own domain because these demand changes sum themselves within the interior transmission-line circuits. It need only compare the algebraic sum of power entering and leaving its domain via the tie lines to other utility companies with the figure that has been agreed upon and scheduled. This sum is appropriately termed the *net interchange*.

The Niagara Mohawk Western Division has four main tie lines. These ties connect to Hydro Electric Power Commission of Ontario (300-0-300 Mw)*, Niagara Mohawk Central Division (300-0-300 Mw), Pennsylvania Electric Company (100-0-100 Mw) and New York State Gas & Electric Company (100-0-100 Mw).

As long as the utility is satisfying its tie-line commitment and the system frequency is maintained, it is servicing its customers. Whenever the customers' needs change, the direction and amount of any overall change is the only knowledge the control system needs to effect the required generator change; this is provided by summing the information from the tie-line pickups.

Thermal converters at the tie lines to other utilities measure the direction and amount of power being exchanged at each tie. Signals carrying this information are telemetered to the central office in downtown Buffalo. Here the signals are added algebraically and the net figure compared to the scheduled net interchange figure by a slide-wire compare circuit (Fig. 2).

Any errors between actual and scheduled net interchange, or between system frequency and desired frequency, are added algebraically and presented as area requirement or, as preferred by Niagara Mohawk, "regulating error." Any deviation of the "regulating error" from the zero position initiates control action. Fig. 3 is a simplified block diagram showing these basic control relationships.

If the deviation is momentary, a fringe (proportional) signal is developed; if the deviation is prolonged, an additional sustained signal results. The fringe part of the control signal immediately calls for a change in generation proportional to the load change.

*Capacity of the tie line in megawatts.

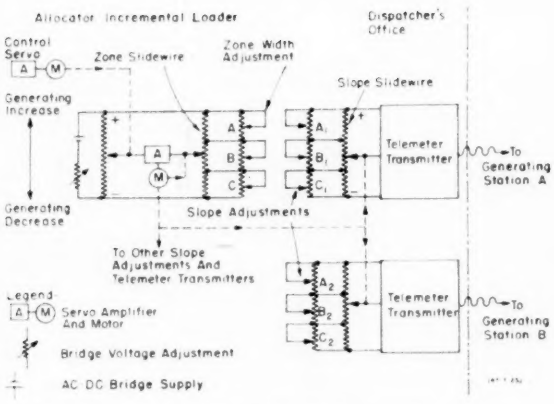


FIG. 4. INCREMENTAL LOADERS apportion command signal (received from control servo) between stations so that each follows optimum heat-rate curves with changing demand. Note that incremental loader is a function generator.

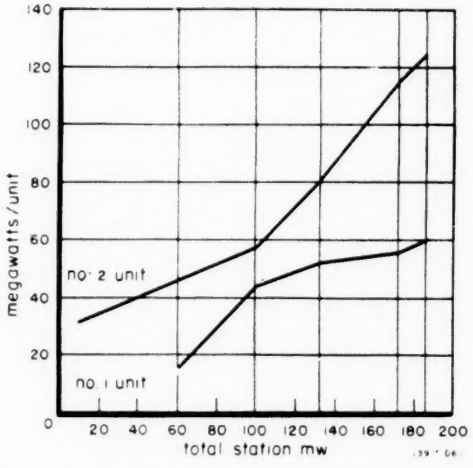


FIG. 5. TYPICAL unit incremental cost-loading curves for a two-unit station, as set up by incremental loader.

Thus, the fringe action reduces the effect of short-time load upsets on the system.

For the sustained load changes, the control action is by the reset mode of control. The combination of fringe plus sustained control holds generator swings to a minimum. Both fringe and sustained response are sufficiently adjustable to take care of foreseeable changes in the Niagara Mohawk Western Division for years to come.

Incremental Loader

The command signal can be either transmitted directly to the stations or routed through an *incremental loader* (Fig. 4). The incremental loader apportions the command signal among the stations so that each generates its optimum *economical* output for any given system load.

The incremental loader comprises a function-generating bank of pots that are set manually to represent the optimum heat-rate function that has been developed by tests for each station and generating unit: this curve is based on fuel costs, depreciation, efficiency, maintenance, and any other pertinent factor. For example, in Fig. 5, if 100 megawatts are to be generated at the station, 44 megawatts should be taken from no. 1 unit, 56 megawatts from no. 2 unit.

Provisions are made also for the introduction of penalty factors for individual stations; a transmission loss computer can be incorporated to compute penalty factors automatically. The combination of incremental loading and automatic computing of transmission-loss penalty factors would provide a completely automatic control system.

Incremental loaders are used primarily in steam electric plants. They are optional but are usually preferred. As a station or unit is placed on automatic control, an incremental loader immediately puts it on its loading curve at the position required by the total load demand. Once break points and slopes are set and a unit or station is placed on automatic control, no further manual operations are required to keep the unit or station at the optimum point of its loading curve from minimum load to full load.

Fringe as well as sustained changes can be sent through the incremental loader so that all changes are made on an economic basis, although the fringe signal can be bypassed around the incremental loader if desired. The signal then transmitted to the station represents the megawatt level at which the plant should be generating.

At the power station the incoming set-point command signal is divided according to incremental loading curves for the individual generating units, (Fig. 5).

Alarms

The control system is engineered carefully to include all alarms necessary to warn the dispatcher and station operators of unusual conditions. There are failure alarms, deviation alarms, and high- or low-limit alarms. Alarms are included for telemetering failure, frequency differential, and high and low limits on net interchange, area requirement, station loads, and generator loads.

Telemetering

Telemetering must be continuous and high-speed so that effects of changes caused by the control sys-

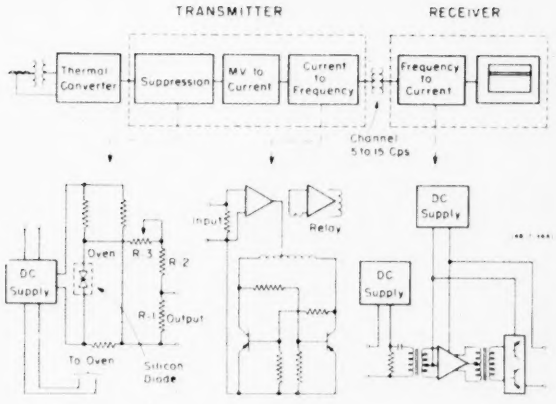


FIG. 6. BLOCK DIAGRAM and circuit schematics for telemetering tie-line power data.

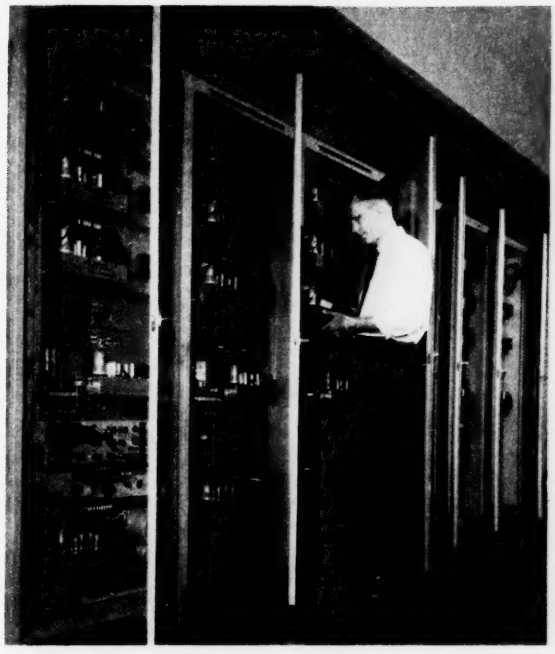


FIG. 7. THESE RELAY RACKS in the Huntley station contain all devices for receiving command signal from the central dispatching office in downtown Buffalo and incrementally loading each generator for highest operating efficiency. Shown are electronic servos (top and bottom of racks), high and low limit alarms, governor motor actuator, rate limiter, power supply and telemetering receivers.

tem are noted immediately and reflected back into the computing circuitry of the control system. Reliability is of paramount importance in a telemetering transmitter and receiver. The third design criterion is that the system should be suitable for use with all communication media—telephone lines, power-line carrier, microwave, tone multiplexing, etc.

The flow of power over tie lines at an interchange point is measured by means of a conventional thermoverter which puts out a millivolt signal proportional to power flow (Fig. 6). The millivolt signal is converted to a direct current at a higher level by means of a transistorized amplifier and a magnetic amplifier. This device, called a "millivolt-to-current" unit, serves the dual function of building the current signal up to a usable level and at the same time isolating the thermal converter to prevent high burdens from being placed on it. The d-c signal, which varies from 4 to 20 milliamps, is then fed to a current-to-frequency converter. This is a transistorized oscillator in which the frequency is changed from a low of 5 cps to a high of 15 cps by the current from the millivolt-to-current unit. Thus, for each value of input current there will be a specific frequency at which the oscillator will oscillate, and the pulse rate is a function of the flow of power over the tie line. The oscillator activates a series of relays which can place voltages on telephone lines used as a transmission media.

The telemetering receiver (Fig. 6) first squares the received pulses to eliminate the noise effects from the transmission line. These pulses are then fed into a saturable transformer which converts them to constant-energy pulses, the average of which becomes a d-c output used to feed the telemetering receiver. Telemetering distances on this system range from 6 to 70 miles.

One of the earliest problems encountered was one of telemetering accuracy. It was found that all available telemetering systems varied in accuracy with temperature, voltage, and frequency variations. Therefore a new telemetering system was brought into being. The completely tubeless devices use the latest solid-state concepts and will hold within plus or minus 1% accuracy through a temperature range of 30° to 120°F.

Servos

Servo units are used in many places throughout the control system. A servo unit consists of an amplifier, a motor, and a motor-driven slidewire mounted on a relay-rack panel (Fig. 7). Slidewires that are precise enough to be used in computing systems in many cases are not sufficiently rugged to withstand the day-in day-out service which an industrial load and frequency control system must withstand. The initial experience with slidewires in this installation showed them to be adequate functionally, but physically weak. From previous experience with slidewires a suitable

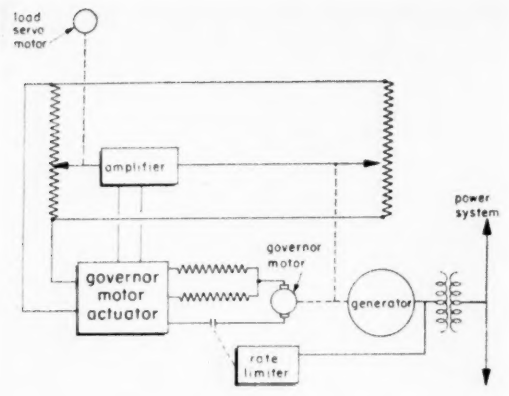


FIG. 8. RATE LIMITER between actuator and governor motor breaks command signal when generator output swings too far or too fast.

slidewire with sufficient ruggedness, linearity, and physical size was designed. These have been in service continuously for more than 18 months, and a close examination of them shows no sign of wear.

Rate Limiter

Early in the program it was apparent that a conflict would develop with respect to the speed of response of the load-frequency control system and the response of the turbines and other generating elements. The control system should operate as rapidly as possible. On the other hand, the limitations of the boiler and turbogenerator combinations are such that it becomes necessary either to make slow changes in the over-all system loading, or to limit the magnitude of fast excursions.

Rather than accept the compromise position that one or the other of the conditions would have to take precedence, the approach taken was to use a combination of the two premises—that is, to permit the electrical generation to change as rapidly as system demands might necessitate within the *safe limits* of operation of the expensive steam and turbogenerator equipment. (The Niagara Mohawk units are limited to a maximum sustained rate-of-change of load of four megawatts per minute to prevent possibility of water being drawn into the turbine.) This is accomplished by a device known as a rate limiter.

The rate limiter recognizes the *magnitude* of a rapid *change*. If the magnitude of the change called for is greater than the preset limit (which can be from 2% to 20% of capacity as determined by the boiler and turbo combination), the rate limiter interrupts the signal (Fig. 8) for a predetermined time. Subsequent reconnections and interruptions permit a continued increase in generation toward that which is needed to satisfy the system requirements, but at a rate which is safe for the associated equipment. The rate limiter continuously adjusts itself to the average value around which it is working. Both the rate of change and the instantaneous step values which a generator can take are adjustable in both the raise and lower directions.

The generator output voltage and current are fed to the rate limiter through the instrument current and potential transformers which are found on all utility measuring instrumentation. A phase discriminator converts the a-c generator output power to a proportional d-c voltage.

The rate limiter is an advancement in the art of instrumentation in that the control requirements can be satisfied while still protecting the expensive generating equipment. The control signal is permitted to change as rapidly as the load demands. Generators vary in their ability to handle load changes; the limiting action of the individual rate limiters on each generator permits the system to be tuned for optimum performance.

Fail-safe circuitry has been used wherever possible to inactivate the control system and sound an alarm should there be a failure of the rate limiter.

Governor Motor Actuator

The position feedback used in the initial installation was inadequate to maintain incremental loading within the limits originally set up. Tests on the generators showed a surprising amount of hysteresis and nonlinearity in the various units. It was considered essential that feedback from the output of the generator be used to meet the incremental loading standards set up.

Hence the *governor motor actuator*, a magnetic amplifier device, was developed to meet this need. It receives a command in terms of a voltage which is proportional to the generation required of the generator under consideration. This signal is compared to a feedback signal of generator output and, if an error exists, a series of magnetic amplifiers amplify the error signal so as to move the governor motor, thereby changing the generator load until the command signal is matched. This unit was given extensive field tests to prove the adequacy of design.

Operational Results

Actual tie-line net interchange follows the schedule closely. The chart for regulating error shows that total swings are held within ± 25 megawatts even when the over-all load increases rapidly during the morning pick-up. Deviation in heat-rate from preferred loading averages less than 2%.

Equipment Achievements

These new achievements are the major ones accomplished on this project:

1. Generator output control using solid-state devices, resulting in good control plus adhering to economic curves.
2. Rate limiting based on output, and independent of the control system.
3. New, accurate, transistorized telemetering.

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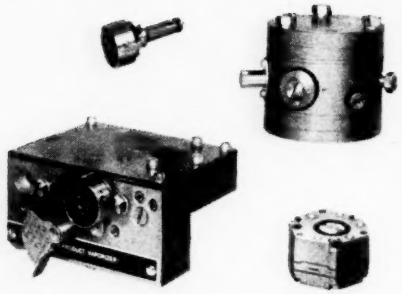
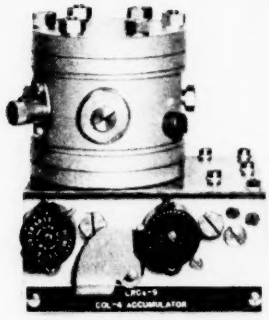
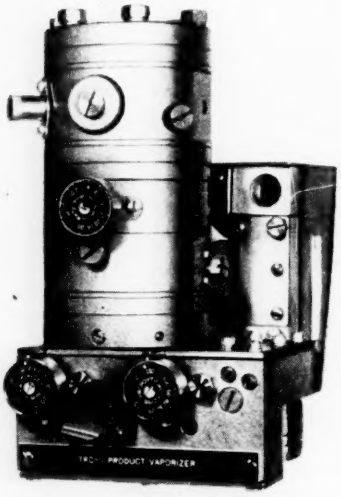
BROWN INSTRUMENTS
First in Controls



Easily disassembled—Unitized construction of all controller components simplifies maintenance . . . makes reassembly foolproof. No need to dismantle stack to clean pilot assembly.

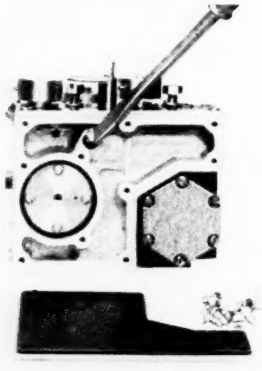


Easy accessibility—All adjustments, filters, and restrictions are easily reached on the face of the controller. Control action is reversed by turning reversing plate 90 degrees.

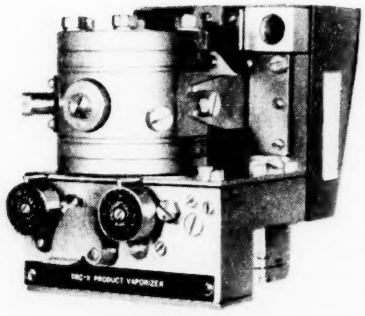


Rate action easily added—Add rate action simply by removing deviation section, inserting longer studs and rate unit, and replacing deviation section.

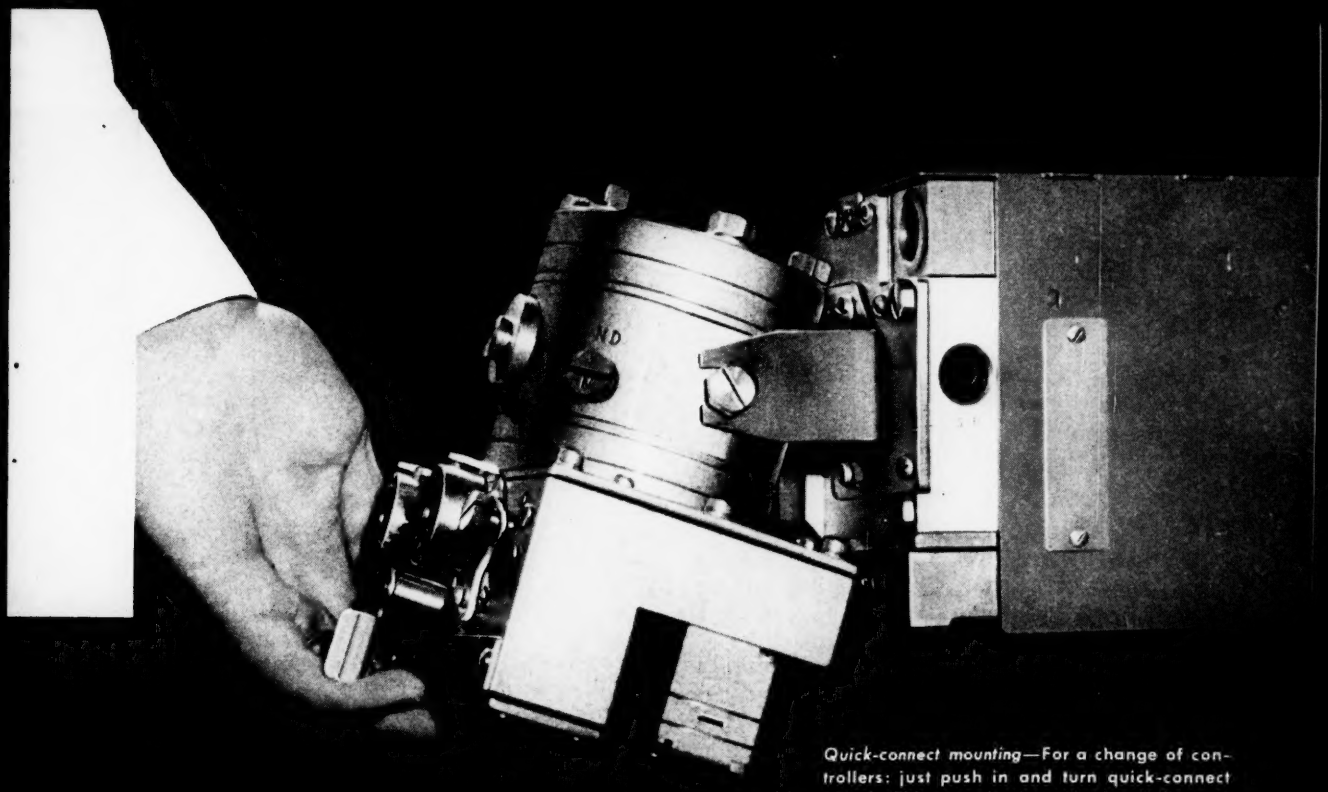
with the simplicity of



Three ranges of reset rates—Move a single sealing screw for choice of three reset ranges: 0.2-100, 0.01-5, or 0.04-20 repeats per minute.



Field-mounting manifold—Furnished for installations where controller is not mounted on the recorder. Has same quick-connect arrangement as rear of recorder, and external reset feedback or bypass relay for bumpless transfer from automatic to manual conirol.



Quick-connect mounting—For a change of controllers: just push in and turn quick-connect switch. This completely seals the air lines to the controller, permitting removal of the unit while process remains on manual control.

TEL-O-SET* controllers

New and improved *Tel-O-Set* controllers are low in cost, easily installed, compact, and require minimum maintenance. You can use them to control any process variable. One basic model serves for all applications. You can mount the controller anywhere: rear of receiver case, back of panel, or on the valve.

With all their simplicity, these instruments are highly sensitive and respond instantly to change. They operate on a pneumatic-balance principle which eliminates lost motion and friction.

Tel-O-Set controllers are an ideal complement to *Tel-O-Set* recorders and indicators... today's most advanced miniature instruments. For details, call your nearby Honeywell sales engineer. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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First in Controls

RICHARD RIMBACH
Publisher

Publisher's Report on European Instrumentation and Automation

PRESENT FOREIGN MARKETS for American instruments probably can be held for the next two years. Although European instrument design and manufacturing techniques are forging ahead in every way, and although the instrument profession abroad has made great strides, European automation still depends on American instruments in a number of key fields. It will probably continue to do so at least until devices now in the prototype stage go into production. Then we can expect real competition down the line.

This is the conclusion of the author, gained after a two-and-a-half week trip which involved contact with the leaders of the industry in Great Britain and Western Europe. I conferred strenuously in London, Paris and Milan, in addition to spending a week as a participant in INTERKAMA (International Kongress mit Ausstellung fuer Messtechnik und Automatik) at Duesseldorf (the first German instrument and automation show).

I left October 27th for this survey and study tour. Advance arrangements had been made for my meeting with instrument manufacturers, consulting engineers, engineering society officials, trade association executives, and editors of instrument and automation publications. The trip was planned for the express purpose of studying markets for American instrument manufacturers.

The instrument industry is moving ahead rapidly in Europe today. Progress, from the standpoint of the instrument engineering profession, is most encouraging even though it portends eventual serious competition for American instruments in world markets. It behooves the American instrument industry to place its products before the instrument users abroad. Such opportunities are offered by the International Automation Expositions in the United States and overseas exhibitions in England, Germany and Italy.

Instrumentation and automation are receiving a big play in the countries I visited, as is evidenced by the organization of societies, instrumentation-automation exhibitions and the starting of publications[1]. I found interest in automation particularly intense in Italy. There recently has been great interest by European industry in the developments in automation by American industry.

Economic conditions in Europe have changed considerably since my visits in 1950[2] and 1953. Labor rates have increased considerably, but productivity has not kept pace with the increase in wages. The damage due to World War II has largely been repaired; the shops have a plentiful supply of goods; there is no shortage or lack of variety of food of all kinds. The restaurants and places of amusement are filled with happy people.

There appears to be a slight labor shortage as is evidenced by the longer work week. Automation is a magic word and everyone is interested in the latest information on automation from America. French and Italian industries in particular are interested in automation but feel that their engineers are not fully qualified to install the necessary systems and therefore look to the United States for guidance.

France

The French industrial economy is expanding rapidly despite France's political troubles, and continuing demands for modern instrumentation have almost surpassed domestic production. United States products are well received by the French, especially industrial and process instruments and automatic controls.

The most serious obstacle is growing inflation and its effect on monetary confidence. In France the importation of instruments and devices for automation has dropped owing to growing inflation. While I was in Paris the franc slumped to a new low on the free market, hitting 469 francs to the dollar. The official rate is 420, established last August 10th in a partial devaluation move to curb imports and boost exports. The internal exchange rate is pegged at 350 francs to the dollar. It must be pointed out that the quantities of United States instruments imported have been limited mainly by the relatively high landed costs of such instruments and devices. There also are opportunities in the growing French industry for licensing of special United States developments for manufacture in France. In the industrial instruments field, a number of French companies are producing this type of equipment under American license.

[1] *Instruments and Automation*, Vol. 30, 1957, pages 2255-2259.

[2] Report in *Instruments*, Vol. 23, 1950, pages 906-907.

VIEWS OF THE LUNCHEON IN ITALY (l to r): Renzo Curti, Secretary, Associazione Nazionale Industriale dell 'Ottica; Aldo Banderali, Trans World Airlines; Rimbach; Guiseppe Zucconi, Secretary of the Magazine, Strumentazione: Mesure e Regolazioni; Luigi Braga, Consulting Automation Engineer, Consultant to the Comitato Nazionale per la Produttivita; Carlo Rossi, President, Associazione Nazionale Italiana per l'Automazione; Bruno Pontremoli, Consulting Engineer; Giovanni Boggi, Consulting Engineer; Luigi Craici, Secretary, Instituto d'Informazione e di Assistenza per l'Automazione.

The French industrial instrument industry is well organized, but United States products in this field continue to be in high demand throughout French industry. Industrial instruments average about 70% of the total United States instruments exports to France, which in 1956 was about $5,000,000.

THE PARIS MEETING WAS in the Hotel Meurice and the following attended:
Jean Auricoste, Societe d'Electronique et d'Automation and Secretary, Congres International de l'Automatique; Jacques Boutig, Specialites Trianty; Dr. V. Broida, Prof., Conservatoire National des Arts et Metiers; Marcel Chalvet, President, l'Association des Ingenieurs Electroniciens and Member Centre National de l'Automatisation; Marcel Douchez, President, Chambre Syndicale des Fabricants d'Appareils de Régulation et de Controle Industriel; Maurice Lachen, Editor, **Automatisme;** André Loury, President, Syndicat Général de l'Optique et des Instruments de Précision; C. W. Olliver, Editor, **Automation** and **Revue Mensuele de l'Industrie Francaise;** Elio Rosa, Instrument Engineer, Lummus Co. (stationed in France); Sam Peters, President, Metalmaster Corp. (Newark, N. J.); Victor Spahn, Manager, Societe Promesur; P. J. Sullivan, Manager, Minneapolis-Honeywell Regulator Co. of France; Francois J. Trochet, Chief Engineer, Chantiers de l'Atlantique; Jacques Viel, President, Société pour la Fabrication et la Vente d'Appareils Hydrauliques de Régulation; Jean Vivie, Editor, **Mesures & Controle Industriel.**

Italy

The fields most favorable for increased imports from the United States are:

1. **Flight navigation instruments**
2. **Geophysical instruments**
3. **Electrical measuring and test instruments**
4. **Automatic process controllers**
5. **Nuclear radiation instruments.**

United States instrument manufacturers are faced with the fact that the Italian Government is reluctant to grant dollar licenses when similar imports can be obtained from soft currency areas. This difficulty may be overcome by establishing Italian or European manufacturing subsidiaries, as already accomplished in a big way by United States companies in Great Britain. Of course such British subsidiaries also share in this import market without the currency difficulties facing these imports direct from the United States.

Owing to the increased activity in Italian mineral research, the Italian market should remain a good one for United States sales of geophysical instruments.

Trade sources are convinced that the expanding Italian economy will require an increasing quantity of precision instruments which probably will be secured from England, Germany and the United States.

Germany

West Germany's recovery is little short of miraculous. A remarkable revival of science and technology has taken place in Europe since World War II. Especially in Germany, damaged research laboratories have been entirely rebuilt and expanded, and many new ones founded. The internal market for scientific and industrial instruments therefore is a large and growing one.

VIEWS OF BOOTHS of American Instrument Manufacturers and of their subsidiaries at Interkama.

A LUNCHEON FOR A NUMBER OF HONORARY GUESTS followed INTERKAMA opening. At the table with the writer from the left in rotation around the table were Dr. Georg Brinkmann, Executive Secretary, Verband fuer Feinmechanik und Optik; Dr. Karl Aller, Industrie- und Handelskammer of Duesseldorf; Dr. Heinz Pietzsch, Chairman, Main Committee for Interkama 1957; Helmut Bornemann, German Post Office Department and Dr. Walter Reidel, Professor, Frankfurt/Main.

VIEW OF ONE OF THE EXHIBITOR CLINICS. In all 47 clinics were arranged by 26 exhibitors. Each clinic was devoted primarily to discussion of one particular instrument or family of instruments.

SOLEMN MOMENT AT A LIVELY PRESS CONFERENCE. During INTERKAMA Fritz Reuther entertained editors of the technical and scientific press. Herr Reuther, of Bopp und Reuther, specialists in liquid metering instruments, is at the head of the luncheon table. Second from his left is the author. At this luncheon liquid metering wasn't once mentioned. Instead there was a spirited discussion of the generalized impact of automation.

The West German instrument industry, particularly the optical and electrical branches, was extensively damaged during the war and subsequently suffered from dismantlement and later expropriation in the East Zone.

Imports account for only a fraction of internal consumption and represent specialist items which cannot be readily obtained in West Germany. Examples: from Holland, polarographs and the more expensive photometers; from Great Britain, advanced spectrographic apparatus; from the United States, spectrographic apparatus and a wide range of electronic devices, electronic computers, etc.

The standardization of instruments and automatic controls in the West German chemical industry is exceptionally well organized through the Normenarbeitsgemeinschaft fuer Mess-und Regeltechnik in der Chemischen Industrie. There is no instrument society in West Germany.

West Germany's rapidly expanding economy has alerted its manufacturers to the need for increased scientific research, and the greater use of process control instrumentation. The resultant rising demand for scientific and industrial instruments provides a market for greater United States instrument sales. The rapidly increasing consumption of industrial instruments in Germany points out the most favorable field for aggressive development by United States manufacturers.

West Germany is enjoying a boom unparalleled in the Federal Republic's history. The economy has been operating nearer its ceilings in manpower, productive capacity, and raw materials than at any other time since the war.

Postwar reconstruction of the major instrument plants has permitted the installation of the most modern machinery in plants laid out in accordance with advanced engineering principles. West Germany thereby has a great advantage over other countries.

Owing to the strong competitive position of the West German instrument industry, the most likely increase of United States exports to this area is in the field of such scientific instruments as flight and navigation instruments, nuclear radiation devices, radar, inertial guidance, aeronautical research equipment, geophysical prospecting apparatus, and certain physical and chemical instruments which incorporate new ideas or represent significant improvements over German models. Optical measuring instruments (mostly spectrophotometers) have averaged 30% of optical instrument imports.

Licensing arrangements may offer promising possibilities of gaining greater access to the West German market. The mutual exchange of licenses and patents between the United States and West Germany may prove advantageous.

INTERKAMA (Internationaler Kongress mit Austellung fuer Messtechnik und Automatik)

Industrial exhibitions play a far more important part in the European economy than in the United States. This may be, in part, the result of long established custom, but it may also be due to the need for

THE COMMITTEE MET WITH THE PRESS on the opening day of INTERKAMA. (Left to right) A. Rittrich, Publicity Director; H. Seifert, Acting Exhibit Manager; Dr. H. Pietzsch, Chairman of the Interkama Main Committee and Manager, Wernerwerk, Siemens & Halske AG.; Prof. Dr. Richard Vieweg, Chairman of the Praesidium of Interkama, and President of the Physikalisch-Technischen Bundesanstalt; Dipl.-Ing. E. Hammann-Kloss, Chairman, Instrumentation Committee, Zentralverband der Elektrotechnischen Industrie, and Director, Hartmann & Braun AG; Dr. B. Sturm, Chairman, Normenarbeitsgemeinschaft fuer Mess-und Regeltechnik in der Chemischen Industrie, and Instrument Engineer, Bayerwerk, Leverkusen.

more effective means and facilities for communicating technical information.

For ten days, Duesseldorf was the Automation Capital of the World. Visitors came from 65 nations, with a reported attendance of 30,000.

The official opening of the Congress was on Sunday in the Rhein Halle with over 2000 present. Dr. Richard Vieweg, President of the Physikalisch-Technischen Bundesanstalt, presided at this meeting.

I was immensely impressed by the tremendous size (240,000 square feet) of Interkama. By any yardstick it was several times as large as the International Automation Expositions or the instrument shows in the United States. Utilizing the facilities of the Duesseldorf fair grounds, a half dozen buildings were filled with 285 exhibits. Most of the "stands" were equivalent to 6 to 8 American exhibit booths. The average exhibit space at the Interkama was 850 square feet (space per exhibitor in the United States averages about 150 square feet).

THE MEETING IN DUESSELDORF, held at the Industrie Klub, was attended by: Hans Albert, President, H. Maihak, A. G.; Jakob Bauer, Regelungstechnik published by Oldenbourg Verlag GmbH; Dr. Victor Conrad, International Management Consultant; Walter Meinecke, President, Dreyer, Rosenkranz & Droop AG; Gerd Mueller, Secretary VDI/VDE Committee on Automatic Control; Dr. Rudolph Oetker, Research Engineer, Siemens & Halske A. G.; Chairman, VDI/VDE Committee on Automatic Control; Fritz Reuther, President, Bopp & Reuther GmbH; Karl Rimbach, West Berlin Sales Promotion Consultant; Dr. K. W. Schwab, District Manager, Trans World Airlines; Dr. Berthold Sturm, Instrument Engineer, Bayerwerk-Leverkusen, and Secretary Normenarbeitsgemeinschaft fuer Mess- und Regeltechnik; Dr. Heinrich Toeller, Director of Research, Hartmann & Braun A. G.; Hubert J. Velten, President, Askania Regulator Co. (Chicago); F. Wessemann, Chairman, Combustion Committee, Verein Deutscher Eisenhuettenleute.

The exhibitors were distributed as follows:

German	**176**	**American**	**7**
Italian	**28**	**Dutch**	**6**
French	**27**	**Danish**	**2**
British	**21**	**Belgian**	**1**
Swiss	**17**	**Hungarian**	**1**

The larger booths had private conference rooms where coffee, tea or cognac was served while application engineers plied their trade.

The following societies arranged the congress, technical sessions and special engineering meetings:

Verband Deutscher Elektrotechniker;
Verein Deutscher Eisenhuettenleute;
Verein Deutscher Ingenieure; and
Normenarbeitsgemeinschaft fuer Mess-und Regeltechnik in der Chemischen Industrie.

Measurement and control committee meetings of the societies were also held. The technical program consisted of ten sessions at which 41 papers were presented under the direction of seven societies. Reported total attendance was 3000.

The exposition was arranged by the following trade associations:

Verband der Deutschen Feinmechanischen und Optischen Industrie
Vereinigung Deutscher Elektrizitaetswerke
Zentralverband der Elektrotechnischen Industrie

The exposition exhibitors were, therefore, from the industrial and scientific instrument fields. Precision measuring instruments and tools were not included (manufacturers of these devices are members of the Vereinigung der Werkzeugmaschinenfabriken).

A special scientific display on units and standards of measurement was arranged by the Deutsche Museum, Munich; the Physikalisch-Technische Bundesanstalt, Braunschweig; the Landesreichdirektion, Cologne; and the Rationalisierungskuratorium der Deutschen Wirtschaft, Frankfurt/Main.

During my attendance at Interkama, I met with a committee of engineering societies' executives to discuss the organization of an instrument technicians' group in Germany. At this meeting a committee was formed to consider the matter further.

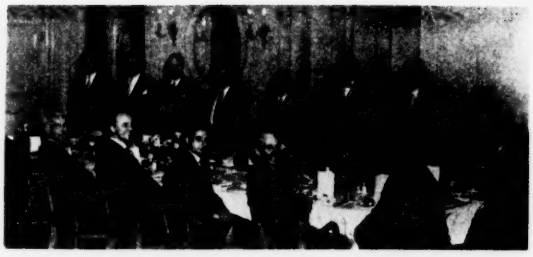
Britain

A significant factor resulting in better industrial instrumentation for British industry has been the increased use of American engineering and construction companies in the British petroleum industry.

The British instrument industry still does not find need for aggressive selling in England. A decided change in the instrument industry's attitude toward the import of foreign instruments into England is evidenced by the change of the Instruments, Electronics, Automation Exposition from national to international. The next exposition, to be held April 16-25, 1958, is promoted by the following trade associations: The British Electrical & Allied Manufacturers' Association, The British Industrial Measuring & Control Apparatus Manufacturers' Association, The British Lampblown Scientific Glassware Manufacturers' Association, The Drawing Office Material Manufacturers'

DISCUSSING THE STATUS of the instrument industry in Yugoslavia with Dr. Vladimir Muljevic, Yugoslavia.

DISCUSSION OF INSTRUMENTATION in Britain with Horace Stevenson, Managing Director, Alexander Controls, Ltd. and H. W. Blake, Secretary, British Industrial Measuring & Control Apparatus Manufacturers' Association, before the London luncheon.



VIEW OF THE LUNCHEON IN THE ADAMS ROOM at the Piccadilly Hotel, London.

Standing (left to right): Bertram Murcot, London office, Instruments Publishing Company; John Hughes, London office, Instruments Publishing Company; Leonard Goodman, British Electrical Development Association; Richard Rimbach; A. G. Peacock, Managing Director, Mervyn Instruments; Horace Stevenson, Managing Director, Alexander Controls, Ltd.; Dr. Vladimir Muljevic, Professor, University of Zagreb, Yugoslavia.

Sitting left to right: Alex Nathan, Secretary Engineering Industries Association; W. G. Norris, Director, Leonard Hill, Ltd., Publisher of Automation Progress; E. G. Semler, Editor, Automation Progress; J. T. Miller, Editor, Instrument Practice; Gordon W. Watkins, Director, Instrument Practice; Fred Davies, Executive Secretary, Federation of British Industries; L. N. Pearce, Manager, E. R. Howard, Ltd.

Not shown: Frank Dawe, President, Dawe Instruments, Ltd.; E. W. Battey, Publisher, Instrument Review; H. W. Blake, Executive Secretary, British Industrial Measuring & Control Apparatus Manufacturers' Association.

& Dealers Association, The Radio Communication & Electronic Engineering Association, and the Scientific Instrument Manufacturers' Associations of Great Britain.

Summary

Two conditions operate against the export of American instruments and automatic controls to Europe.

1. **The European Common Market**
2. **The unfavorable currency situation**

The second condition is also beginning to react against Germany as the Deutsche Mark is the hardest currency in Europe.

European governments are reluctant to grant dollar licenses whenever similar imports may be secured from soft currency areas. This difficulty may be overcome by establishing subsidiary companies in these countries, as has been extensively done by American companies in Great Britain. Such operating subsidiary companies in European countries also share in the market represented by the European Trading Area without the currency difficulties faced by those importing directly from the United States.

Progress abroad has stimulated a greater demand for automation know-how. Overseas companies are eager to share information on a reciprocal basis.

While the European common market threatens to discriminate against U. S. exports, it stimulates the flow of American capital to Europe. Many American companies now exporting to Europe will set up plants there.

Very few instrument manufacturers on the Continent are conscious of the importance of advertising in reaching prospective customers. They consider advertising as too expensive but spend many times the annual advertising budget for exhibits in fairs.

	Hourly rate of a first class instrument mechanic	Exchange rate per dollar Nov. 1957	Hourly rate in dollars	Cost of a Pair of shoes	Cost of a Pack of cigarettes	Hours worked without overtime pay	Normal working hours per worker	Overtime pay per hour in percent of hourly rate	Annual product of precision industry (est.)
England	6½ shillings	7 shillings	0.90	60 shillings	3.5 shillings	44	50	150%	$500 million
France	300 francs	350 francs	0.87	3500 francs	100 francs	40	45	125%	$160 million
Germany	3.5 marks	4.19 marks	0.83	25 marks	2 marks	45	45	125%	$500 million
Italy	400 lire	625 lire	0.64	4500 lire	150 lire	44	48	125%	$100 million

Journal of the S C M A . . .

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Electric Control-Valve Operators

This thorough résumé of available and experimental electric-powered control-valve operators investigates the inherent problems, describes the various solutions to these problems, analyzes economic factors, and outlines the improvements to be expected in future developments.

GLENN F. BROCKETT
Fisher Governor Co.

RECENT DEVELOPMENTS in the instrument industry reveal a trend to greater use of electronics. This trend toward electrical instrumentation has not been revolutionary, but it is persistent and significant of things to come. Many of the major petroleum and chemical companies have evidenced enough interest in electrical instruments to either make a trial installation or to at least investigate the advantages of doing so. Most of these trial installations apparently have had a considerable measure of success, although certain weaknesses have appeared.

People who champion the cause of electronic instrumentation claim that electronic devices are inherently sensitive, have small dead bands, lend themselves ideally to miniaturization, make long-distance transmission practical, and are almost a "must" for use with data handling and computer systems.

On the other hand, recent surveys on process control instruments indicate that further development in the direction of lower costs, simplicity of construction, ease of maintenance, and dependability is urgently needed. Lack of a standard signal range is also a deterrent to the industry at the present time.

Of all the elements in the control loop, the control valve or final control element has been the most difficult to convert from pneumatic to electric operation. Development of a satisfactory modulating-type electrical control-valve operator is difficult fundamentally because of the large-scale intermittent power requirements. All of the methods so far discovered for converting electrical energy into sufficient power to operate even a medium-sized control valve incorporate a rotating electric motor. The problem then becomes one of converting the torsional force thus produced into a reciprocating motion for positioning the plunger of a control valve, and of controlling this motion.

It might be well to mention at this point that control-valve designers have not been entirely unaware of the fact that the present-day sliding-stem body assembly might not be the most ideally suited to electrical operation. However, the development of a completely new valve assembly is such a lengthy and costly reasearch project that manufacturers have adopted the obvious expedient of designing an electrical operator that can be adapted to available valves. A completely new valve may be evolved in the future.

Also presented at Texas A & M Symposium, June, 1957.

FEBRUARY MEETING: Thursday, the 20th, Rio Hondo Country Club, Downey, California.

FEATURES: Mr. T. M. Morrow of the U. S. Naval Ordnance Laboratory, Corona, California, will talk on: Metering Problems in the Navy Calibration Program. Mr. R. G. Edholm of the General Electric Company, Milwaukee, Wisconsin, will speak on: Use of X-Rays in Process Control.

Operator Requirements

In order to compete with pneumatic control-valve operators in the process industries, electrical operators must:

1. Be completely self-contained, requiring no inputs other than the electric control signal and a-c power from the distribution line.
2. Have the ability to operate directly in conjunction with all commercially available process controllers with their varying output signals.

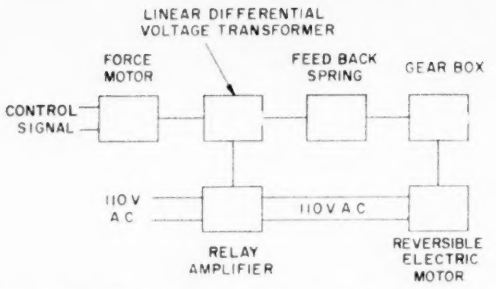

FIG. 1. BLOCK DIAGRAM of geared electric-motor operator.

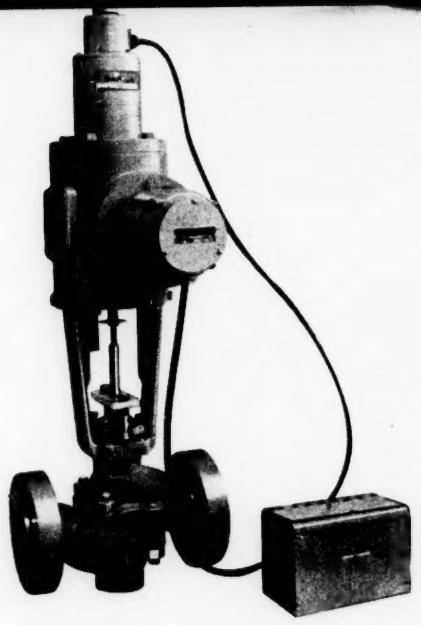

FIG. 2. GEARED electric-motor-operated valve.

3. Be able to perform at least as well as the pneumatic counterpart from the standpoint of positioning accuracy, available thrust, and speed.
4. Be available in an explosion-proof case for hazardous locations.
5. Be reasonably simple and easy to service.
6. Be rugged enough to withstand the abuse it is sure to get in a large industrial process plant.
7. Be reliable enough to give trouble-free operation over a period of years.
8. And last, but not least, be priced within reason.

Of these requirements, simplicity, ruggedness, reliability and low cost are the most difficult to achieve.

An electric valve operator incorporating an electric motor driving the valve stem through a gear box, with appropriate controls, would seem to be the most direct approach to our problem. The power input would be employed directly, without conversion to another operating medium. This would apparently result in a savings in conversion component costs, conversion inefficiencies and complexity. However, a comprehensive analysis of the possibilities with this type of actuator bring out some fundamental weaknesses. The maximum torque that can be exerted by the rotor of an electro-magnetic machine is a function of the strength of the magnetic field which is created. If we consider even the most desirable of modern magnetic materials, we find that we can achieve a maximum effective "magnetic pressure" of the order of 50 psi. On the other hand, if we are to get good frequency response and speed of operation, the inertia of the rotor must be kept low. It immediately becomes obvious that a combination of high stem thrusts and rapid response in a device of this type is difficult to accomplish.

In addition to the fundamental disadvantage in the torque-to-inertia ratio, we are faced with the necessity of providing satisfactory gearing between the motor and valve stem. Gears of any kind are undesirable from the standpoint of backlash.

Basic Electric Operator

Despite these inherent obstacles, direct-drive modulating operators have been designed and are available to process instrument men. Fig. 2 is a block diagram that shows the essential elements of the assembly shown in Fig. 1. In this arrangement, the controller signal is fed to a small force-motor or "voice coil" which is linked mechanically to the core of a linear differential voltage transformer, which serves as a null-type motion detector. The current produced by the motion detector is fed to a relay amplifier to operate one of two relays. The relays apply 110-volt a-c current to the forward or reverse winding of a low-inertia electric motor. The motor drives the valve stem through a linear-motion gear box. A force-balance type of feedback is accomplished by a spring attached to the valve stem, which resets the core of the linear differential voltage transformer and the force motor.

This operator is relatively small and compact and is advertised to deliver a maximum thrust of 500 lbs at a stroking speed of 1" in 15 seconds. This is probably about the optimum performance that could be expected from an operator of this type. It is doubtful if it could be made powerful enough to operate large valves against high pressure-drops without some form of electric braking on the motor. This would be complex and expensive.

Electrohydraulic Operators

As an alternate to driving the valve directly by an electric motor and gear box, designers have turned to an intermediate self-contained, hydraulic transmission system. In its simplest form, an electric motor-driven pump provides a continuous source of high-pressure fluid for positioning the main operating piston, which is directly attached to the valve stem. The flow of oil to the piston is regulated by a hydraulic servo valve which is positioned by a small force-motor in response to changes in the signal from the controller. As in the geared controller described

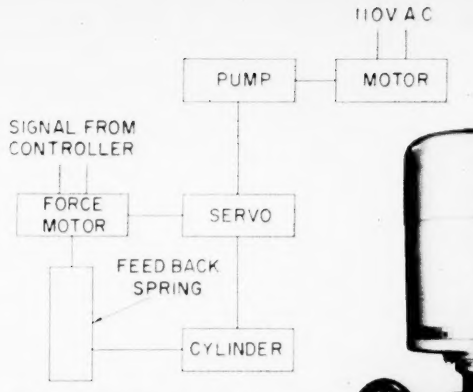

FIG. 3. BLOCK DIAGRAM of simple electrohydraulic operator.

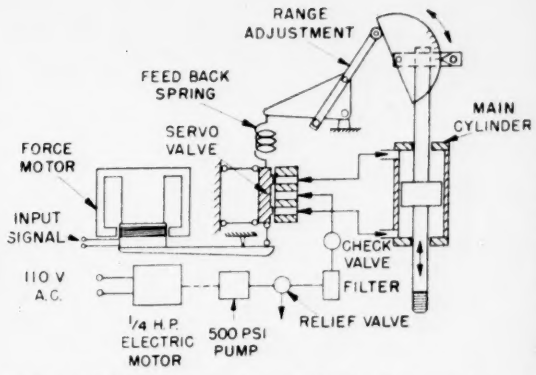

FIG. 4. SCHEMATIC of electrohydraulic operator.

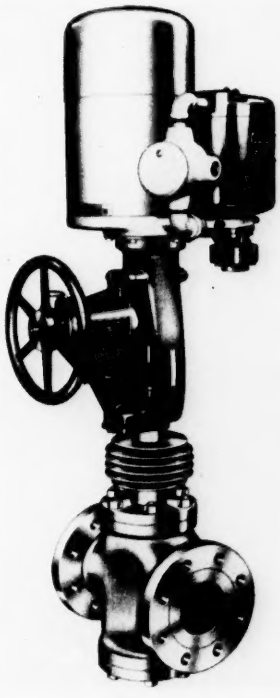

FIG. 5. ELECTROHYDRAULIC OPERATOR mounted on valve with manual operator.

previously a force-balance type of feedback is accomplished through a spring which is loaded by movement of the main valve stem to reset the force motor and the servo. A block diagram of this system is shown in Fig. 3.

A commercial adaptation of the design is shown schematically in Fig. 4 and Fig. 5. It is powered by a 110-volt a-c ¼-hp motor which drives the rotary gear pump. The pump delivers oil to the hydraulic system at 500 psi. The hydraulic system consists of a relief valve, a filter, a check valve, a servo-valve and a double-acting power cylinder. The servo valve is positioned by the force motor that is, in turn, powered by the instrument signal. Feedback and range adjustment are provided by linkages and a spring between the main cylinder shaft and the movable member in the servo valve. This model is advertised to deliver a maximum thrust of 1,250 lbs with a stroking speed of 1" in 3 seconds. By using a larger power piston, more thrust can be obtained, but the speed will be decreased proportionately.

All of the components of this general design are well known and are available in commercial forms. The servo valve, however, has proven to be a stumbling block to many designers. Servo valves (or four-way pilot valves) of a sliding spool design (Fig. 6) have been used for many years in aircraft controls, gun pointing mechanisms, etc., and are available from several manufacturers. They have a high power gain and excellent frequency response, but they are extremely sensitive to dirt particles in the hydraulic fluid, and their cost is high due to the close manufacturing tolerances required.

The design represented in Fig. 4 (marked servo) and shown enlarged in Fig. 7 was developed by Lee and Shearer at the Massachusetts Institute of Technology and is described in A.S.M.E. Paper No. 54-A-196. It is produced by drilling holes simultaneously through metal plates that slide against each other in the final assembly. Its advantage lies in the fact that it has no extremely difficult machining tolerances. The moveable plate is supported by two flexure strips. Adaptations of this design are being used by at least two electrohydraulic-operator manufacturers.

Jet-Pipe Operators

Another manufacturer offers a jet-pipe type of servo (Fig. 8). In this comparatively simple system the force motor positions the jet pipe or nozzle to discharge into one or the other of two adjacent receiving orifices, which are connected directly to the actuating cylinder. The secret of success of this type of servo is the high degree to which the jet-pipe system has been developed. With oil pumped at 160 psi from the jet, 90% pressure recovery is achieved in the receiving orifices. As in the previous model, the feedback is accomplished by a system of levers and a spring between the main operating shaft and the force motor.

The manufacturer of this unit offers automatic shut-off valves in the lead lines to the power cylinder, which lock the valve in place upon loss of power. This is a desirable feature that could be added to any operator using a hydraulic system and a piston.

This model is advertised to produce a maximum

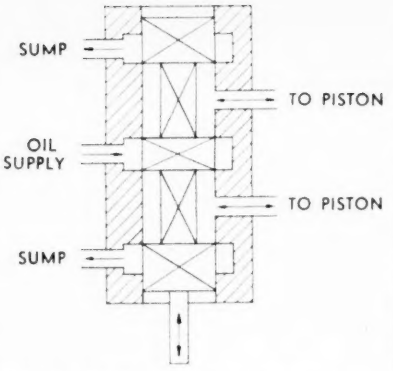

FIG. 6. SPOOL-TYPE 4-way hydraulic servo valve.

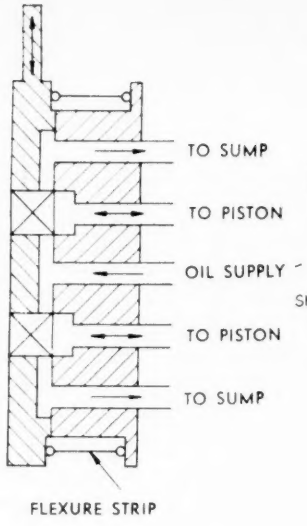

FIG. 7. SLIDING-PLATE-TYPE 4-way servo valve.

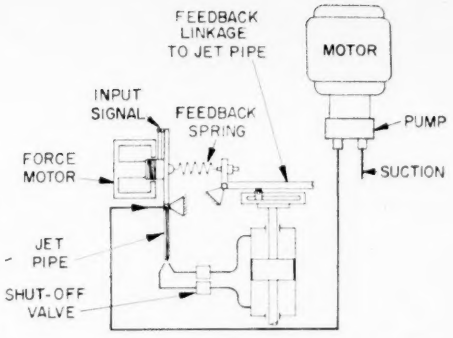

FIG. 8. SCHEMATIC of electrohydraulic operator with jet-pipe servo.

stem thrust of 600 lbs with a stem speed of 1" in 2 seconds at no load and 1" in 5 seconds at 600-lb load. This operator is not as powerful or as sensitive as some on the market, and its frequency response is not as good, but it probably would be quite dependable as a result of its simplicity and large, wide-open oil passages.

In the designs so far considered, we have used the power from the controller signal to drive a force motor directly. This controller signal has not been standardized, and as yet no two electronic process-control-instrument manufacturers use the same signal. For example one American manufacturer offers electric process instruments with signal current and load requirements of 1 to 5 milliamps and 3000 ohms maximum; another uses 1 to 5 milliamps and 12,000 ohms $\pm 0.5\%$; a third uses 0.3 to 5 milliamps and 8000 ohms maximum. From the standpoint of the valve manufacturer, it is desirable to use as large a signal as possible. It is not practical to design a force motor that will produce more than a few ounces of force with 4-milliamps input. Many designers feel that this is not adequate to provide the dependability of operation (of the servo valve) that is a prerequisite in an industrial quality operator.

Electronic Amplification

The alternative to more power in the signal is amplification of some kind. By the addition of such an amplifier the power to the force motor can be increased until several pounds of force are available to operate the servo valve. An electric amplifier also makes it possible to provide electric feedback from a linear differential transformer attached to the main valve shaft. The amplifier can be of vacuum-tube, transistor, or magnetic type. The magnetic or transistor types are, of course, most desirable.

Fig. 9 shows a commercial operator that incorporates an electric amplifier with electric feedback. Fig. 10 shows an external view of this operator mounted on a control valve. This is a null-type system and, when it is in balance, the force motor and servo valve are centered, and no oil flows to the main cylinder. The piston is stationary and the error voltage is zero. When a signal change from the controller is transmitted to the summing amplifier, it is compared to the feedback signal from the linear differential transformer. The difference or error voltage between the control signal and the feedback signal is amplified and transmitted to the force motor which moves the servo valve. This permits a flow of hydraulic fluid to move the main piston and displace the core of the linear differential transformer. The feedback signal

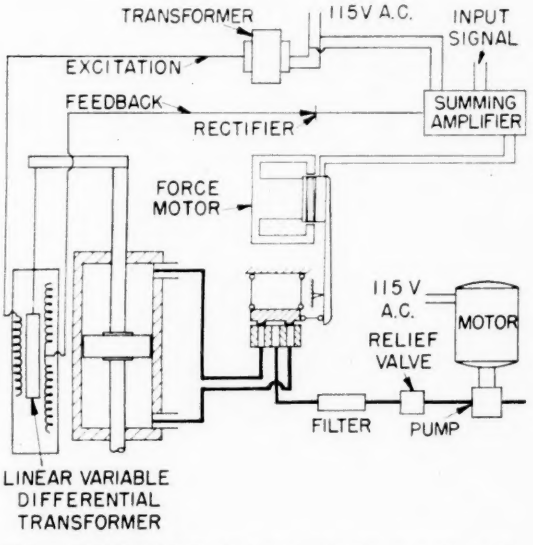

FIG. 9. SCHEMATIC of electrohydraulic operator with electric amplifier.

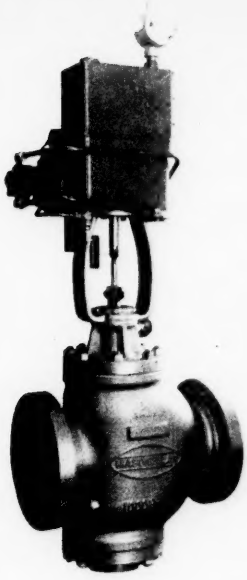

FIG. 10. ELECTROHYDRAULIC OPERATED control valve.

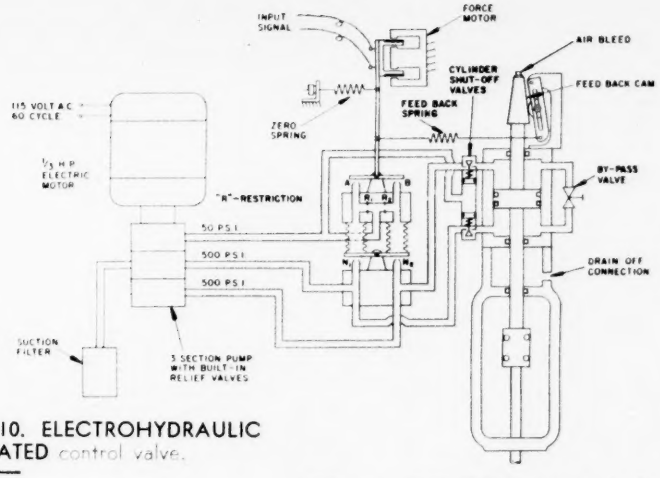

FIG. 11. SCHEMATIC of electrohydraulic operator with hydraulic amplifier. Complete unit is shown in Fig. 12.

thus generated is transmitted to the summing amplifier, and the force motor and servo are reset to center.

This operator has good stability, excellent frequency response, precise positioning ability, and speed and power that are a function of the pump capacity and piston size. However, it is too expensive and complex to be practical for use on the average process-control-valve application.

Hydraulic Amplification

The use of a hydraulic amplifier between the force motor and the servo valve is also a possibility that should be considered. Much less force would be required to operate a hydraulic pilot or amplifier than would be required for the main servo valve. A system such as this would be less costly than the electrical amplifier type and would be particularly attractive if a somewhat higher control signal could be used to operate a more rugged force-motor.

Fig. 11 shows one of the many possible variations of this principle. Note that it is analogous to many pneumatic controllers. In this design the pump is made up of 3 sections, two of which deliver oil at 500 psi through 2 separate lines for positioning the main operating cylinder. The third section delivers oil at 50 psi as a power supply for the hydraulic amplifier. The amplifier section consists of 2 orifice-nozzle combinations which control the pressure in 2 bellows. A T-shaped beam attached to a force motor throttles the discharge from the nozzles in response to input signal changes. The resulting bellows movement controls the flow from two large nozzles in the 500-psi pump discharge lines.

Shut-off valves in the lines to the main cylinder are closed by failure of the 50-psi amplifier pressure. Mechanical feedback is provided through a spring.

The unit, shown in Fig. 12, is available from a manufacturer of control valves who advertises a stem thrust of 2000 psi, with a stroking speed of 0.37 inch per second.

Magnetic-Fluid Operator

Many other systems have been tried in the laboratory and found to be unworkable or impractical for one reason or another. One unique design that did not prove practical, but that might be of academic interest, is a magnetic-fluid valve operator designed by Armour Research Foundation of Illinois Institute of Technology.

This design is based on the use of a magnetic field for controlling the flow of a mixture of oil and iron particles into the stroking cylinder (Fig. 13). The operation is similar to that of a four-way hydraulic valve. When a control current is passed through one set of coils, for example B and C, the magnetic fluid in these coils aligns the iron particles in the mixture and causes it to become quite viscous. This effectively impedes the flow through these two branches. The remaining two branches, providing an unimpeded path, allow oil flow to move the cylinder in one direction. The reverse action is obtained by passing control current through coils A and D. The magnetic field can be varied continuously from 0 to some maximum value to provide continuous control of the velocity of the stroking cylinder.

This type of control, used with a summing amplifier and electrical feedback, proved to be capable of high power gain and fast response. However, further testing by Armour Research led to the conclusion that pump seals and particle settling were insurmountable obstacles at the present time, and the idea was discarded.

The Future

Most manufacturers who have entered the electric control-valve field do not as yet offer an adequate range of sizes. It seems logical that at least three operator sizes would be desirable to handle valve sizes from 1" to 16". This lack of an adequate size range presents a serious problem to anyone currently interested in equipping an entire process plant with electrically operated instruments and valves.

◄ FIG. 12. ELECTROHYDRAULIC operator with hydraulic amplifier.

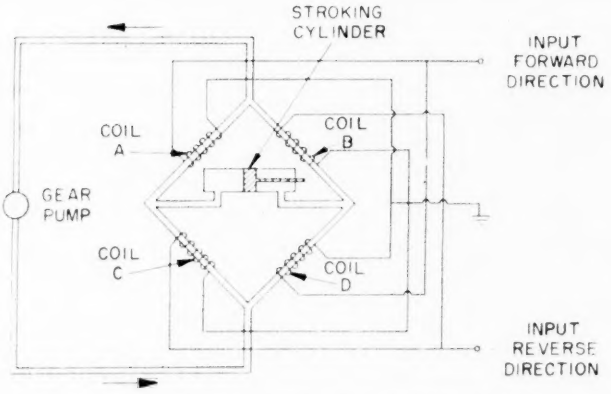

FIG. 13. MAGNETIC-FLUID valve operator schematic.

No doubt there are many new and clever ideas for electric valve operators on drawing boards and in laboratories at the present time, and it is not unreasonable to assume that some of these will prove better than any yet offered. Rapid and far-reaching progress is certainly to be expected in an industry as young and important at this one.

After reviewing some of the various types of electric valve operators now on the market and considering some of the fundamental design problems involved, we conclude that it is possible to produce a self-contained modulating electrically powered operator for present-day process control valves that will perform as well or better than pneumatic operators. These operators can be made to meet all normal thrust and speed requirements, to position with a high order of accuracy, and to have excellent frequency response. In addition to this, if a hydraulic piston is used, a stability or "solidity" of positioning is achieved that overcomes a serious weakness present in all pneumatic diaphragms or piston operators. The pneumatic diaphragm or piston is a resilient assembly that moves in response to dynamic forces transmitted from the inner valve or plug by the valve stem. On the other hand, the hydraulic piston is positioned by a noncompressible fluid that dampens vibration and prevents jumping of the inner valve and resultant rough control and wear on the valve components.

It now appears that in its present stage of development, the electrically powered operator is not able to compete economically with the simple spring and diaphragm pneumatic operator. When we consider that a pneumatic operator for a 2″ or 3″ valve with a pneumatic positioner has a price tag of about $160.00, and that without the positioner it cost only about $70, we must concede that the electric operator priced at $400.00 and up is going to be hard to justify from a dollars-and-cents viewpoint. This is particularly true in the process plant that already has an adequate instrument air system and where plant additions or modifications only are being considered. Even in a new plant where electric instrumentation is being used, the complete air system for the operation of control valves probably could be justified only if 100 or more valves were involved.

Combination Systems

A satisfactory installation can be made using electric or electronic instruments and pneumatic control valves. Electropneumatic transducers for converting the control signal to a pneumatic one are simple, not too costly, and available.

Also, electropneumatic valve positioners that operate from an electric signal but have a pneumatic output to a diaphragm motor are available and have been used extensively. This type of positioner used with a conventional diaphragm motor is a great deal less expensive than any equivalent all-electrical operator yet conceived, and will require less maintenance. Its ultimate performance may not be as good, but it is satisfactory for most process applications.

On the other hand, there are applications involving long transmission lines and remote control valves where the greater expense of an all-electric valve may be justified. Examples of such applications would be automatic transfer systems on tank farms, or pipeline controls. Also in extremely cold climates where air lines are susceptible to freezing, electric operators may be easier to justify. Further it is probable that many of the processes of the future will be so complex and so demanding in instrument performance that only the most advanced electrical valve operators can measure up to the requirements. It is in such a plant that electric instrumentation all the way to the final control element will come into its own. In the meantime, it behooves the instrument and valve designers to develop and improve their products so that our industry will not be found wanting when the need is at hand.

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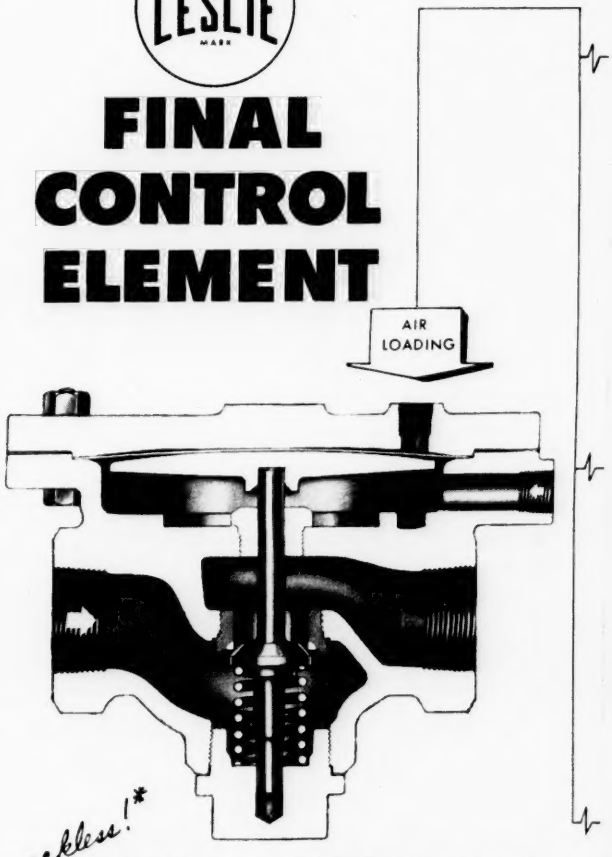

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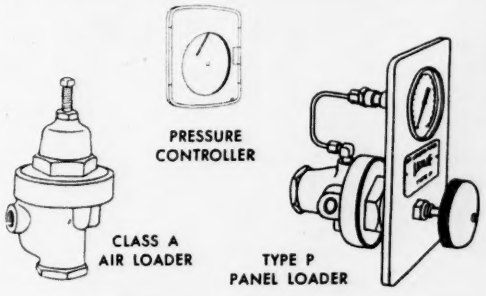

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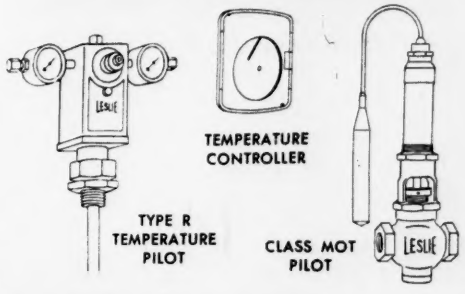

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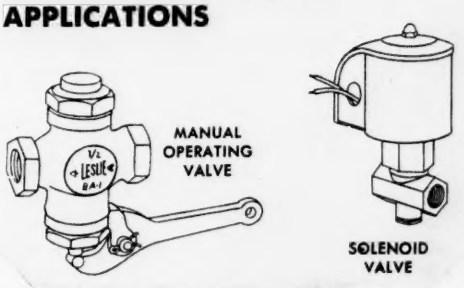

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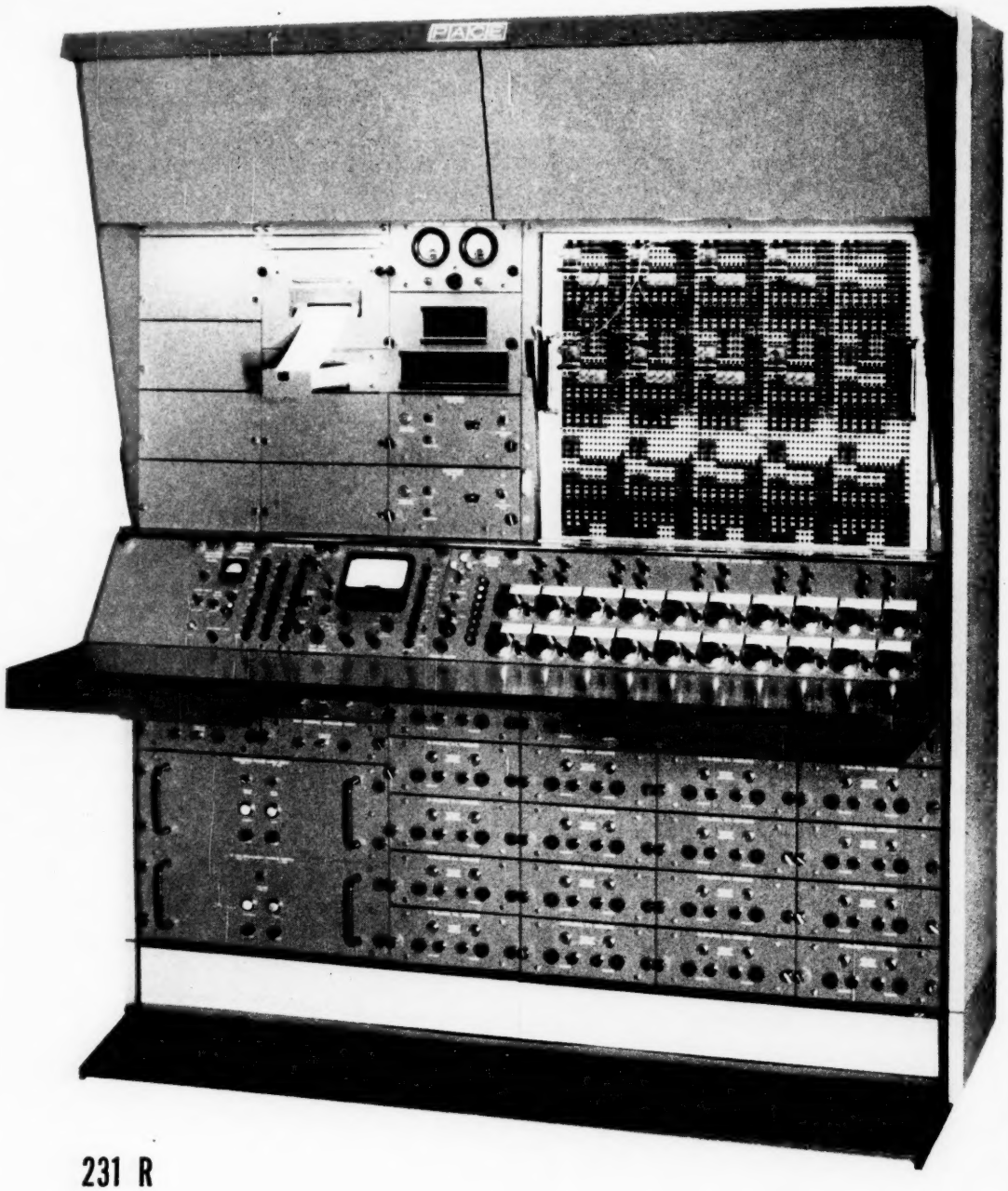

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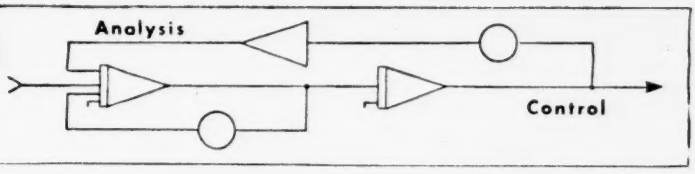

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Bits

This month we have Ed Holmes' notes covering the Southeastern Simulation Council meeting on Analog-to-Digital Conversion, which we have condensed considerably because of previous writeups on the same subject in these columns.

We also offer a rather complete version of Harold Ehler's recent Western Simulation Council presentation from which only the detailed math has been deleted. Harold described work done at Autonetics to standardize frequently-encountered aerodynamic equations, and a method of mechanizing these standardized equations for the analog computer which might be compared with the use of subroutines for digital computers.

Este mes no mas, señoras y señores.

Pieces

SE S/C MEETING OF 27 SEPTEMBER ON ANALOG-DIGITAL CONVERSION

On September 27, 1957, Radiation, Inc., was host to a meeting of the Southeastern Simulation Council, when 33 members met at the Belcelona Hotel in Melbourne, Florida, to discuss "Analog-to-Digital Conversion." After a welcome and a short history of the Simulation Councils by *Dave Prince* (Federal Telecommunications Lab., Atlanta, Ga.) each person present introduced himself.

Hoeppner on Analog-Digital Conversion

Ed Holmes (E. G. Holmes & Assoc., Atlanta, Ga.) then introduced *Conrad Hoeppner* (Radiation, Inc.), who described some problems of analog-digital conversion and methods of overcoming them:

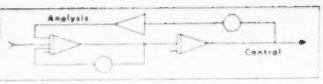
(1) Establishing a binary number by first comparing a voltage equal to one-half the range of the converter with the unknown voltage. If the latter is greater, the most significant binary digit is a 1, and the unknown voltage is next compared with a voltage equal to $^3/_4$ of the converter range. Again, if the unknown voltage is greater, the second most significant binary digit is a 1 and the next comparison is made against $^7/_8$ maximum voltage, etc. Comparisons whenever the unknown voltage is smaller of course result in a zero, and a reduction in the reference voltage for the next comparison.

(2) Mr. Hoeppner also described the 640 fixed-styli plotter manufactured by Radiation which actually plots digital information in such small increments that it appears to be in analog form.

Asked by *Dave Prince* if he would care to speculate on the future of a-d conversion systems, Mr. Hoeppner answered: "I foresee the development of transducers which will provide digital output directly. Since it is desirable to obtain the digital form as soon as possible, some day we will see accelerometers, pressure pickups, temperature pickups, etc. whose output will be the exact digital code desired."

Burns on A-D Converters in Systems

Ed then introduced *Meryl Burns* (Radiation, Inc.) who discussed "Analog-to-Digital Converters as Applied to Simulation Systems." Mr. Burns pointed out that in data-processing applications it is sometimes necessary to convert analog information to digital form because of the mathematical processes involved. He first described a digital-to-analog converter whose output can be fed to an analog computer for certain mathematical operations.



The output of the analog computer can then be fed to an analog-to-digital converter. This is particularly useful when computations are required on a real-time basis.

Mr. Burns also described a digital delay synthesizer. The analog input goes into an analog-to-digital converter, the output of which is fed into a high-speed digital memory. A control device can then program the output from the memory to a digital-to-analog converter to subsequently recover the analog information when and as desired.

Dave Prince commented that the delay is limited by the storage capacity and went on to say that for alarm applications in logging operations the average of several samples is desired, as well as the digital value of each sample.

Graeber on Shaft-Angle Digitizers

The next speaker, *Ralph Graeber* (RCA, Patrick Air Force Base, Florida), gave "A Review of Shaft-Angle Digitizing Systems" in which he described many shaft-angle digital encoders which are now in use or have been described in the literature. At present there are three general categories: (1) The brush-commutator units, (2) phase-comparators, (3) photoelectric types.

In general, brush-commutator units are the simplest and, by the use of tricks such as "cyclic" binary, "V"-brush logic, ambiguity bits, etc., they meet the majority of digitizer requirements. In cases where high inertia, high torque, or gearing is a problem, photoelectric units can be used. Phase-comparison devices are more in the nature of laboratory instruments; however, when properly used, they are capable of high precision. Low, intermediate, or high-precision encoders may be required, depending on the application. A typical low-precision requirement would be the digitizing of various types of aircraft instrument data for use in conjunction with an airborne digital fire-control computer. An encoder now available off the shelf may meet such requirements quite adequately. A digital encoder for precision radar might require intermediate precision. Photoelectric encoders, possibly using cascaded gearing, seem to be the most popular type for this kind of application. In the field of super-precision the phase comparators seem to offer great promise, though units available at present require a good deal of complex electronic circuitry.

Asked by *Captain E. Dingley, Jr.* (Electronic Communications, St. Petersburg, Fla.), what he considered low, medium, and high accuracy, Mr. Graeber replied, "My own classification is that one part in less than a thousand would be low accuracy, one in a thousand to one in a hundred thousand would be medium accuracy, and high accuracy would call for one part in over a hundred thousand."

Leshan on A-D Converters and Data Transmission

The final speaker, *Jay Leshan* (Milgo Corp., Miami, Fla.), discussed "Analog-to-Digital Conversion As Applied to Data Transmission Systems." He described a system which Milgo is manufacturing currently for Patrick Air Force Base to transmit range, elevation, and azimuth information. In this system a set of three analog-to-digital converters feed digitized information to a transmitter. At the receiving end the signals are detected and preserved in the digital form.

The analog-to-digital converter uses an operational amplifier whose feedback resistor is made up of 13 series elements, each of which can be shorted out by means of an individual relay. The output of the amplifier is compared with a reference voltage, and a clock pulse sequentially closes the relays which short the resistive elements of the feedback resistor until the output is equal to or greater than the reference voltage. When this happens a turn-off pulse is fed to the clock generator, and the relay whose closure caused the pulse is left open. The clock generator then closes the next relay unless another turn-off pulse is received, etc.

The turn-off pulses are fed to a single-shot multivibrator, the output of which keys the transmitter to produce a 13-bit code.

Asked by *Bob Marquand* (Radiation, Inc.) how long it takes to sample, Mr. Leshan answered "0.1 second."

Captain Dingley asked whether the data come directly from the radar, and was told "No; another computer does translation and we take their information."

In reply to a question, "How long does it take to sample one bit?" Mr. Leshan said "About three microseconds."

This prompted *Bob Marquand* to ask whether sampling can be done faster than three microseconds.

Mr. Leshan replied that he was sure it could be done in 0.5 to 1.0 microsecond. Then in answer to the question, "How much current is required to switch the cores?" he said, "About 60 milliamps."

Following this discussion the meeting adjourned for lunch, after which the Simulation Council members were conducted on a trip through Radiation, Inc.

WS/C MEETING OF 14 NOV. ON "STANDARD SIMULATION CIRCUITS"

Fifty-nine representatives of 21 organizations gathered at Autonetics, a division of North American Aviation, in Downey, California, on the 14th of November for a meeting of the Western Simulation Council on the subject of "Standard Simulation Circuits."

Ehlers on Standard Equations

Dov Abramis (Convair, Pomona, Calif.), chairman of the Western Simulation Council, introduced *Harold Ehlers* (Autonetics) who presented a well-prepared paper which, with projected slides, described in mathematical and physical detail the work done by his group to standardize and mechanize certain frequently-recurring equations at Autonetics. Some details have had to be omitted from this writeup, but the objectives, methods, and results described should be of interest to all who are concerned with analog computation.

According to Harold, the early designers of the Simulation Facility recognized that they had two basic alternatives in the computer wiring. On the one hand, they could bring the computing element inputs and outputs to an adjustable wiring board and use the computer in a general-purpose manner. On the other hand, if it was decided to use the computer for a single purpose only, they could permanently wire the computing elements to solve this problem. In the latter case, particular

solutions would be obtained solely by adjustment of switches, potentiometers, function generators, etc. The Typhoon computer, constructed for the Navy by RCA, is to some extent an example of a special-purpose facility, designed specifically to solve three-dimensional aircraft flight equations. At first the computing components were not permanently wired, but later modifications have caused significant portions of this facility to be so wired. I believe that if the lessons that dictated the permanent wiring could be expressed by a single word, this word would be *reliability*.

As computer circuits become more complex, even the most skilled troubleshooter is hard pressed to locate a failure. And the time required to troubleshoot goes up markedly with the complexity of the problem. A ball-park figure for a problem containing 150 amplifiers might be one hour. This hour includes the time the operator is unaware that trouble exists, as well as the time required to locate and repair the failure. Intermittent types of failures or simultaneous failures can increase this time appreciably. On this basis a single failure per 8-hour work day would cause a reduction in operating efficiency of 12½%. Eight such failures would mean zero efficiency.

Consider the types of failures which can occur. In the first place there are failures of the electronic equipment—tubes, potentiometers, fuses, switches, resistors, capacitors, etc. An all-out attack has been made on such failures over the past several years with gratifying results. Even so, on a problem of 150 amplifiers and associated computing equipment, we can expect that one or two failures will occur in an eight-hour day. This leaves only about 80% of the day for operating time and for other types of failures. On the Typhoon computer with 400 amplifiers it would not be unreasonable to expect that 50% of the time would be used to correct equipment failures.

A second type of failure is induced by the human operator, who may construct a simulation circuit that doesn't behave as it was intended to, or may make an operational error in wiring, pot setting, or switching. Either a computer or operator error, undetected in the course of a study, might very well invalidate all the data obtained. Hence rigorous time-consuming checking procedures are generally adopted to establish an initial reliable reference solution. These checking procedures frequently consist of: (1) Complete static checks, (2) dynamic checks of portions of systems, and (3) over-all comparison of transient response with data obtained from digital computers.

The permanently-wired special-purpose computer has the advantage that the simulation circuits used are tested and proved, and temporary external wiring is reduced to a minimum with a consequent increase in wiring dependability. However, it has the distinct disadvantage of limited flexibility even on the specific problem for which it was wired.

The advent of the removable patchboard early in the development of the analog computer was a definite improvement. It allowed the storage of tested and proven circuits, but the new patchboard itself had to be very reliable. It has met this challenge of reliability, proof of which is the extensive use made of stored problems in all modern simulation facilities.

But has this method of problem storage eliminated any further need for progress in this direction? Is the efficiency of operation of a modern facility now determined purely by electronic component failures? Has circuit setup and checkout time been reduced to the point at which it represents a minor portion of the operating time? The answer to all of these questions is clearly NO!

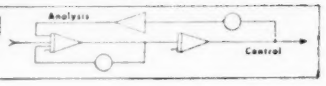
Consider how the removable patchboard is used. An engineer studies the problem which requires investigation and writes the equations describing it. In this he may have a choice of several alternatives, any one of which will give the same final result.

Next he devises a simulation circuit for solving the set of equations. Several different engineers undertaking the same problem would quite probably end up with different circuits.

The problem is then wired on removable patchboards while off of the computer. The wiring is double-checked and the next phase of the problem, verifying the validity of the simulation circuits, begins. During this period circuit modification is made as required, scaling is adjusted, and the human errors are corrected. This phase usually consumes a substantial portion of the initial test period, after which the engineer has a proven simulation circuit. The prepatch boards can be stored and later used for any further tests of the same system with a minimum of preliminary checks, and without circuit modification.

The most costly part of this process is the circuit development and checkout. Can the effort expended on this phase be substantially reduced or eliminated? If an analysis of the problems studied shows that many

WESTERN SIMULATION COUNCIL VISITS AUTONETICS—Harold Ehlers (Autonetics) compares their etched standardized circuit board with a conventionally-wired board for the benefit of John McLeod (Convair-Astronautics, San Diego, Calif.), Jack Sherman (Lockheed Missile Systems Division, Palo Alto, Calif.), Ronald Rodine (Jet Propulsion Laboratory, Pasadena, Calif.), Dov Abramis (Convair, Pomona, Calif.), and other Simulation Council members.



use the same form of equations, then the answer is Yes! But in making the analysis we must remember that the equations for similar problems can be written in different forms, so the similarity may not be immediately evident; the physics of the problem must be studied.

In establishing the standard circuit, certain conditions must be satisfied. First, the various possible applications of the circuit must be determined, and the equations stated in the most efficient form for these applications. Compromises may have to be made, but application of this principle to flight-control problems has been accomplished with little difficulty. Second, the circuit must be independent of the physical size of the object being studied. This dictates that the equations must be normalized. Finally, the standard circuit must be available in such a form that its application can be readily understood by the engineer who will be using it.

The standard circuit bears the same relationship to the analog computer as the subroutine does to the digital computer. Each is a tested, proven, and frequently-recurring portion of whole programs. Standard circuits are applicable to all fields of simulation. As a specific example, consider a typical use—the simulation of aircraft flight-control systems.

A large percentage of the problems solved on the simulation facility of the Flight Control Department of Autonetics is concerned with the dynamic behavior of aircraft and automatic flight-control systems. Perhaps 75% of all our flight-control system studies can be grouped into the following categories:

1. Lateral perturbation
2. longitudinal perturbation
3. longitudinal trajectory
4. five-degree-of-freedom aircraft maneuvers
5. six-degree-of-freedom perturbation
6. six-degree-of-freedom trajectory
7. flare-out for landing.

The similar characteristics that distinguish these studies are:

1. The lateral-perturbation study included airframe simulation of the roll, yaw, and side-force equations with the aerodynamics represented as linear about a specified flight condition.

2. The longitudinal-perturbation study was similar to the lateral-perturbation study, except that airframe lift, drag, and pitching moment equations were simulated.

3. The longitudinal-trajectory simulation was used for missile studies in which the airframe accelerated or decelerated rapidly. The lift, drag, and pitching-moment equations defining the motion of the airframe in the longitudinal planes are simulated with the aerodynamic coefficients expressed as functions of Mach number.

4. The five-degree-of-freedom aircraft maneuver was studied on all high-speed fighter-type aircraft to determine the extent of the inertial cross-coupling that existed during high-speed maneuvers between the lateral and longitudinal planes. The lift, side force, and the three-moment equations were simulated with the aerodynamic coefficients generally expressed as functions of attack and side-slip angles.

5. The six-degree-of-freedom perturbation was used on both aircraft and missile studies when the investigation, among other things, was concerned with speed control. The three-force and three-moment equations were simulated assuming constant aerodynamic coefficients. Generally, the non-linearities associated with gyro signals were represented properly.

6. The six-degree-of-freedom trajectory study varied from the perturbation study only in that the aerodynamic coefficients were now represented as functions of Mach number. This simulation was employed principally in evaluating missile systems.

7. The flare-out-for-landing simulation was employed in evaluating automatic as well as manually-operated landing systems for both airplanes and missiles. The lift, drag, and pitching moment equations were simulated, with aerodynamic coefficients expressed as functions of the angle of attack and nearness to the landing surface.

That part of the simulation which was similar from project to project was the airframe equations of motion. In the cases considered, the airframe represented from 50% to 85% of the total simulation circuit; therefore establishing standard circuits for the airframe represented an appreciable saving in circuit mechanization and checkout time.

Generally, the control system varied to such an extent that it appeared (at least for the present) to be a less fruitful area for circuit standardization. However, it should not be overlooked as an area for further investigation because, by using a subroutine approach, a repertoire of control systems might be devised that could be used in conjunction with the various airframe standard circuits described.

In considering standardization of the airframe equations of motion we should note that there are several separate axes systems which must be resolved:

1. Earth axes, which define the position of the aircraft with respect to the earth.

2. Airframe axes, which define the angular orientation of the aircraft in space.

3. Wind or stability axes, which define the aerodynamic forces and moments.

4. Gyro or inertial axes, which define the gyro signals.

A convenient method of presentation is to write the equations of motion with respect to the airframe axes and, by matrix methods, make the necessary transformation of forces and velocities to and from this axes system. However, each standard circuit must be considered individually, as the method of presentation of the equations which is most efficient for one application is not necessarily best for all.

Harold then described longitudinal-trajectory simulation in detail (too much detail for presentation here). Slides were projected which showed all the equations with definitions of all terms. Then he showed a diagram of the analog computer circuit for solving the equations, with an explanation of the symbology used and of operation of the circuit.

It was pointed out that variables shown in the circuit had a bar above them. The bar indicated that at that point in the circuit the voltage would equal 100 times the ratio of the variable to its predicted maximum value. This normalization procedure solves the scaling problem and enables the circuit to be used on different sizes and types of missiles and aircraft. In the standard circuit the gains are adjusted so that potentiometers are normally set at about 0.2. Analyses have shown that this generally provides adequate range for circuit adjustment.

To use such a standardized circuit the operator must compute an estimate of the maximum values of cir-

cuit parameters, as he would do normally in circuit scaling. These values are entered in a table which lists all parameters in the standard circuit for which maximum values are required. From this, a brown-line copy of the circuit is made to show the exact quantity of each variable at all points of the circuit.

Next, a table is completed listing circuit potentiometer settings as ratios of maximum values of circuit parameters. This operation is arithmetical and can be performed either by technical computer personnel from the listing of circuit maximums, or by a simple program on a small digital computer. This work completes preparation of the airframe portion of the circuit. When the simulation circuit for the control is added, the engineer is ready for the simulation study.

The foregoing technique accomplishes the following:

1. It reduces the time required to prepare the simulation circuit.

2. It provides tested and proven circuits for the airframe simulation.

But having developed a standard circuit, why should it be rewired each time it is used? Wouldn't it be more efficient to have it permanently wired so that only the non-standard part of the system need be rewired for each problem, especially if the standard wiring could be kept separate from the non-standard so that modification of the latter could be made readily?

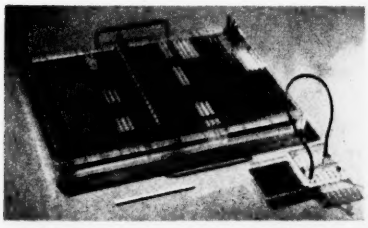


Fig. 1. New patchboard design.

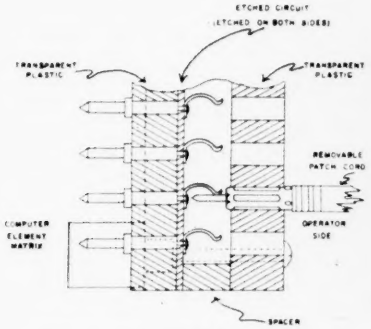


Fig. 2. New patchboard has two levels—standard and non-standard.

New Patchboard Design

This line of reasoning led to a new computer patchboard design (Fig. 1). Fig. 2 shows that two levels of circuit wiring exist. The matrix of pins on the extreme left makes contact with the computing elements. Wiring for the standard circuit is contained within the etched circuit board. A complete matrix of contacts is attached to the etched circuit board; removable patch cords provide access to both the standard circuit and the computing elements not used within the standard circuit.

In the normal use of this board, the simulated control circuit, as well as minor modifications to the standard circuit, are wired externally with the normal type of patch cord. Only a small percentage of wires is changed from project to project and these wires are readily accessible.

Fig. 3 shows the wiring on a normal patchboard, and indicates the difficulty of making control circuit changes. Fig. 4 shows the same problem with only non-standard wiring exposed; we can see the ease with which control-circuit changes can be made using the new pre-patch panel.

Certainly a technique such as Harold described, which reduces set-up time, facilitates trouble-shooting, and increases reliability, is a real contribution to the simulation and analog computation art.

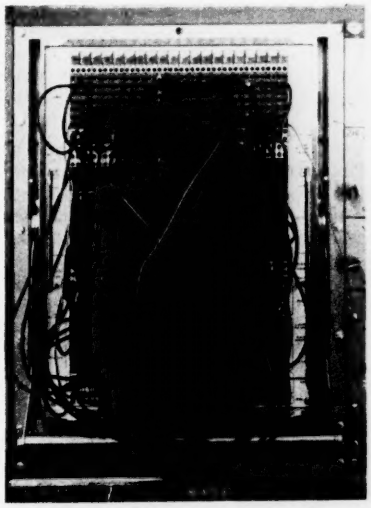


Fig. 3. Wiring on conventional patchboard.

Autonetics Simulation Facility

After coffee and something of a smorgasbord of pastry, courtesy of Autonetics, Harold and his colleagues took us via two buses (these California aircraft factories are really spread out!) to their simulation facility.

The equipment is installed in a straight-line configuration in a rectangular room about 150′ long and 30′ wide. Air conditioning is provided by five units of 7½-ton capacity, which drive air through the computing racks and exhaust into the room. In addition, the room has its own air-conditioning system*.

The power to the computing system includes 60-cycle single-phase, 400-cycle single-phase, and 28 vdc. The 60-cycle power is provided by a transformer which is used exclusively by the computing facility and is capable of providing 200 kw of power. The actual power consumption is approximately 168 kw, 28 of which are required for operation of a Bendix Flight Simulator.

The ±100-volt reference for the facility is provided by a single unit, designed by New Jersey Electronics Company, which can supply five amperes of current. A twin supply is in a standby position to be used in case of failure of the operating unit. These units are used alternately so that the over-all operational hours on each is approximately the same.

*Could this be proselyting propaganda?

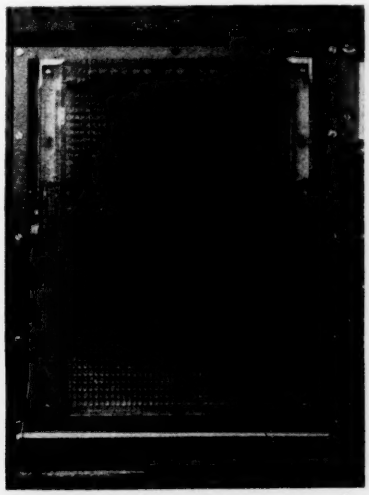
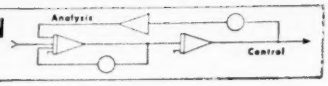


Fig. 4. Same problem with only non-standard wiring exposed.



A high-quality ground bus for the computer is provided by a copper tube of about 2½ square inches cross-sectional area, which is connected to a pipe driven into the ground beyond the depth of local ground water.

There are a total of 464 EA operational amplifiers. Of these, 356 are independent amplifiers with 160 capable of being used as integrators; 36 amplifiers are associated with servo resolvers; 48 are used with the electronic multipliers; and 24 are wired as relay amplifiers. However, all of the amplifier terminals are brought out to the patch bay so that if they are not used in the special-function application they can be used as isolation amplifiers. This equipment also includes 12 precision dual-channel resolvers; 10 channels of time-division-type dual-product electronic multipliers; and 40 servo multipliers, each with five multiplier potentiometers. Fifteen of the servo multipliers have four of the potentiometers with 17 tap points which are brought out to a special unloading control panel. Each of these servos with the tapped potentiometers provides a capacity to generate 60 functions of a single variable.

The Bendix Three-Dimensional Flight Simulator includes, in addition to the three-axis flight table, 78 d-c operational amplifiers, time-division-type electronic multiplers with a total capacity of 15 products of five independent variables, and modulators and demodulators for conversion of signals to and from the flight table.

The recording equipment contained within the facility includes eight Offner 6-channel recorders, two Brush 6-channel recorders, two Electronic Associates 30" x 40" 2-armed vertical plotting boards, one Electronic Associates 30" x 40" single-arm horizontal plotting board, and 10 Moseley 11" x 17" flat-bed-type plotter/curve followers.

This equipment has been used for (1) training of pilots for missile flights, (2) development of flight-control and navigation systems, (3) investigation of airframe structural dynamic loads. In the course of development of the flight-control and navigation systems, the simulation circuitry provided for tie-in of the flight-control system hardware, the AN digital computer, and a full-scale mockup of the hydraulic systems in both planar and three-dimensional simulated flights. The simulation of the flight with the flight-control system hardware involved the use of rate and attitude gyros mounted on the flight table. The pilot training, on numerous occasions, was carried out on a three-dimensional basis in which the aerodynamic coefficients were generated as functions of Mach number as well as of other variables. Cockpit simulation was and is being employed extensively. Numerous simulation studies of rocket engines and nuclear reactors also have been performed.

The Flight Control Simulation Facility equipment is operated on both an open- and closed-shop basis, although the closed-shop approach is preferred. Continual changes and improvement of the computing facility are taking place and the computing consoles are not identical in detail; experience has shown that skilled operators, who are constantly associated with the equipment, can get the most out of it.

Information (Without Theory)

As pointed up elsewhere in this issue of *I&A*, this is the thirtieth anniversary of their publication. Certainly congratulations are in order. The *I&A* circulation of 26,000 attests to the value of the magazine to instrumentation and allied fields.

This is also the fiftieth *Simulation Council Newsletter*, the last 22 of which have been published by *I&A*. Your Editor, in offering his congratulations, would like to add that he has never enjoyed a better business relationship. Both Richard Rimbach, the publisher, and Milt Aronson, the editor, have meticulously kept their part of every agreement—written, oral, or implied. Of greatest interest to my readers is one of the first: That they would not attempt to influence the contents of the *Newsletter* in any way.

While admitting that some professional influence might give you a better *Newsletter*, I am glad to be able to report that no one connected with *I&A* has ever commented on what does or does not appear in the *Newsletter*. Mmmmm—wonder if they read it!

Computer Events

Central Simulation Council Meeting

Date: 3 February 1958; 2:00 PM
Place: Monsanto Chemical Co., Lindbergh and Olive Street Road, St. Louis 24, Mo.
For information write Theodore J. Williams, Research and Engineering Div., Monsanto Chemical Co., Lindbergh and Olive Street Road, St. Louis 24, Mo.
Subject: Four papers on process uses of analog computers will be given.

1958 High-Speed Computer Conference

Dates: 12-14 February 1958
Place: Louisiana State University, Baton Rouge, Louisiana
For information write Dr. Billie Townsend, Mathematics Department, Louisiana State University.

Eastern Simulation Council Meeting

Date: 17 February 1958
Place: AVCO Mfg. Co., Advanced Development Div., 20 S. Union St., Lawrence, Mass.
Subject: Applications of Large-Scale Simulators, Including Environment
Schedule: Steering Committee 10 AM; Tour of facilities 10 AM; Study Groups 11 AM; Technical Sessions 1 PM.
For information contact Hideo Mori, Hydel, Inc.; Robert Yaeger, Electronic Associates.

Western Joint Computer Conference

Date: May 1958
Place: Los Angeles, California

1958 National Simulation Conference

Dates: 23-25 October 1958
Place: Dallas, Texas
The conference will be sponsored by the IRE Professional Group on Electronic Computers and the Dallas Section of the IRE. For information write Louis B. Wadel at 3905 Centenary Drive, Dallas 25, Texas.

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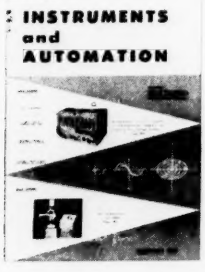

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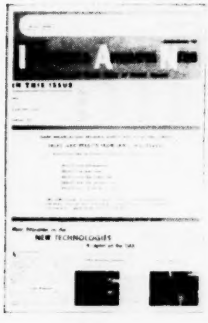

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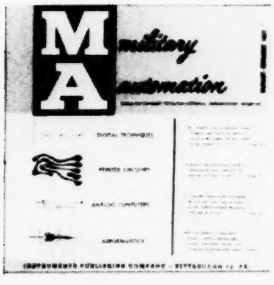

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computing and data processing

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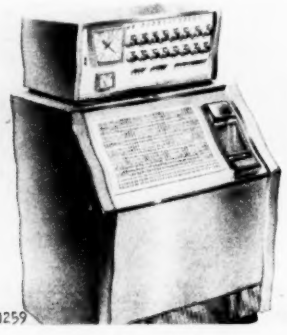

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with all requisite facilities for computations in such fields as guided missiles, cat cracking, proportional mixing, automatic control, etc. It can be used either independently or in conjunction with other computing equipment. It comprises 12 operational amplifiers, 16 scale factor pots, a servo multiplier, 4 free diodes, 2 relay amplifiers, a VTVM, 2 channel oscillographic recorder, and built-in power supplies. Standard equipment includes amplifier overload alarm, fixed type program patchboard with integrator grids to permit use of special feedback components, etc.—*Mid-Century Instrumatic Corp., 611 Broadway, New York 12, N. Y.*

For more information circle **301** on inquiry card.

CHART-DATA PROCESSOR

New Model N-2 of OSCAR features new method utilizing Mylar crosslines as *X-Y* reading references; can be used for reduction of both frame-by-frame film and multiple-trace oscillograms. Output range 10,000 counts in both *X* and *Y*. Plugboard programmer makes N-2 compatible with all existing digital computers.—*Benson-Lehner Corp., 11930 Olympic Blvd., Los Angeles 64, Calif.*

For more information circle **302** on inquiry card.

DATA PROCESSING SYSTEM

New low-cost "VIP" (Variable Intensity Plotter), for quick and easy processing and interpretating seismic data, offers central processing office advantages while preserving transportability: its components are a visual display unit weighing 65 lb and a computing unit weighing 85 lb. System operates on 115 vac 60 cps and consumes about 2 kw. It displays corrected seismic data on a 20" CRT for easy reading and examination, and on a 5" CRT for photography. 24 recording channels can be processed simultaneously in seconds, after normal move-out and time-depth adjustments. Records can be composited to improve signal-to-noise ratio.—*Texas Instruments Inc., 3609 Buffalo Speedway, Houston, Texas.*

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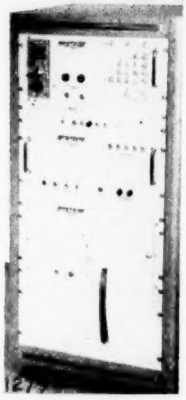
TRANSPORTABLE AN-DIG



New Series 160 Analog to Digital Data Processor, for industrial in-plant use, accepts any variable that can be presented as a voltage; converts it to digital form and makes it available either visually as a direct-reading in-line numerical 3-digit indication, as a number printed sequentially on paper tape, or in punched-tape form. A ten-line code per digit is also available as output to drive various other devices. Models range from single-channel single-output equipments to multi-channel devices with output in several selectable forms. Smaller units can be hand-carried; larger ones mount on rubber tired wheels.—*Systron Corp., 2055 Concord Blvd., Concord, Calif.*

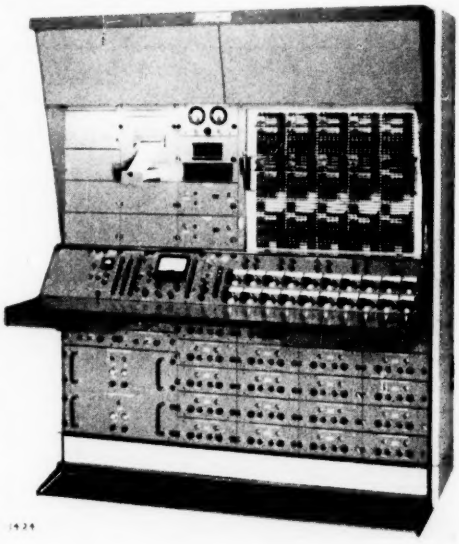
For more information circle **304** on inquiry card.

AN-DIG CONVERTER AND DIGITAL VOLTMETER

New Model 310A multipurpose all-electronic digital voltmeter measures from 000.0 to 120.0 vdc; can be used also as the essential analog-to-digital conversion element in data reduction systems. It displays readings at 60 per second, automatically or on command; and coded outputs of each sig-

ANALOG COMPUTER

New 231-R is said to represent "a major breakthrough in analog computer design and technique . . . the most fully automated and human computer ever designed." Among innovations: modular grouping of components making patching four times faster than previous methods; advances in speed of operation such as AERO (automatic extended readout) which permits entire computer system to be scanned and values printed seven times faster than on other computers; all-electronic digital voltmeter; pot settings at twice the speed of former analog computers; control panel tailored for convenient centralized control, with a high-speed scanning and print-out system (200 points a minute); automatic programming and operation with new ADIOS (automatic digital input-output system).—*Electronic Associates, Inc., Long Branch, N. J.*



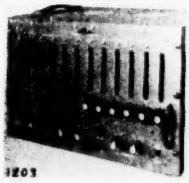
1424

For more information circle **305** on inquiry card.

nificant figure provide a signal source to operate matrices, punches or categorizing equipment.—*Franklin Electronics, Inc., Dept. 375, Bridgeport, Pa.*

For more information circle **306** on inquiry card.

ELECTRONIC INTEGRATOR



New Model 270 Integrating System accepts analog voltage signals, digitizes by heterodyne technique, and integrates area under signal curve (or above a preselected signal level) by counting at rate of 10,000 per second. Both integral and elapsed time are displayed digitally. Instrument provides highly accurate measurements of energy by integrating power *vs.* time, impulse by integrating force *vs.* time, etc.—*Allegany Instrument Co., Inc., 1091 Wills Mountain, Cumberland, Md.*

For more information circle **307** on inquiry card.

TRANSISTORIZED BUFFER

New 144-BQ-8 magnetic core storage unit can be used for delay, temporary storage or buffer; helps pro-

vide compatibility between two data systems having different operating characteristics. It stores 144 characters of 8 bits each; loading or unloading time 14 usec; no transition time required for switching from load to unload mode.—*Telemeter Magnetics Inc., 2245 Pontius, Los Angeles 64, Calif.*

For more information circle **308** on inquiry card.

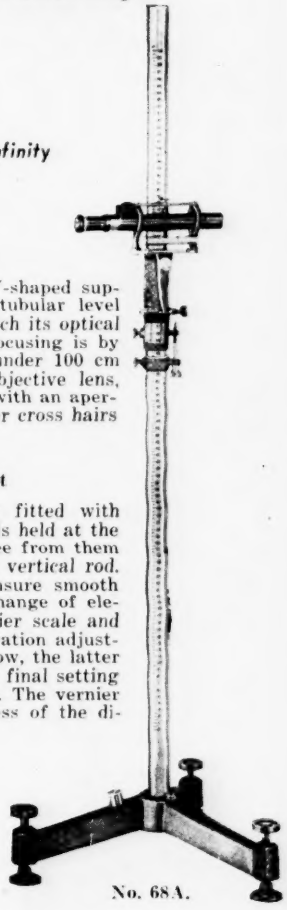
MECHANICAL REFERENCE GENERATOR

New JX. 603-A has been designed for use in servo and allied systems, either by itself or as an auxiliary equipment to maker's Transfer Func-

The Improved Welch CATHETOMETER

Rapid Leveling — Fine Adjustment — Graduations Engine Divided for Uniformity and Accuracy

- *Vertical range 100 cm*
- *Vernier reading to 0.05 mm*
- *Working distance 45 cm to infinity*
- *Magnification 12 x at 45 cm—8 x at infinity*
- *Level sensitive to 50 seconds*



No. 68A.

Rack-and-Pinion Focusing

The telescope is held securely in two V-shaped supports and is equipped with a sensitive tubular level and a fine-motion tangent screw with which its optical axis can be adjusted to the horizontal. Focusing is by rack and pinion. For working distances under 100 cm an auxiliary lens, which fits over the objective lens, is provided. The objective is an achromat with an aperture of 20 mm. An eyepiece with 90° spider cross hairs is employed.

Sensitive Elevation Adjustment

The telescope carriage is individually fitted with great care on the vertical support rod. It is held at the desired elevation by two collars but is free from them and is capable of 360° rotation about the vertical rod. Wide bearing surfaces of the carriage insure smooth rotation about the vertical rod without change of elevation. The upper collar carries the vernier scale and is coupled by means of a fine-pitched elevation adjustment screw to a supplementary collar below, the latter being clamped in position to allow for the final setting of the telescope with the fine adjustment. The vernier scale remains on the main scale regardless of the direction of the axis of the telescope.

Vertical Rod of Stainless Steel

The support rod is rust-proof stainless steel 30 mm in diameter and selected for straightness. The graduations are engine divided for uniformity and accuracy and the numerals are large and clear. It is divided in millimeters.

The tripod base is cast iron with a radius of 21 cm to give ample stability. It is equipped with leveling screws and footplates. A small circular level is mounted in the base for rapid preliminary leveling.

A full-length plastic cover and a set of instructions are included. No. 68A **Each $247.50**

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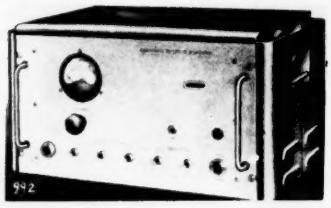
For more information circle **70** on inquiry card.

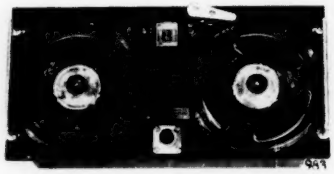


tion Analyzer—whose application is thereby extended to encompass purely mechanical or hydraulic servo systems and electromechanical systems which cannot be tested by means of a purely electrical input signal.—*Solartron, Inc., 10761 Burbank Blvd., North Hollywood, Calif.*

For more information circle **309** on inquiry card.

TAPE RECORDER

New Model TT-100 multi-channel magnetic tape recorder for slow-speed operation can operate from −20°F



to 165°F. Up to three record channels, at speeds from 0.05 to 1.87 ips using ¼" tape on 5" NARTB reels. Instrument runs on 6 vdc.—*Precision Mechanism Co., 922 Terminal Way, San Carlos, Calif.*

For more information circle **310** on inquiry card.

WATER DETECTOR

New BS&W Monitor, designed primarily for detection and control of basic sediment and water in crude

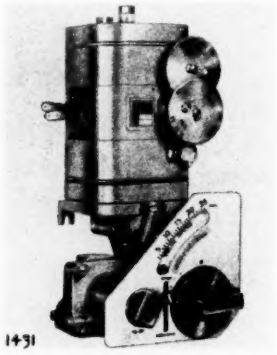
oil, is essentially a dielectric constant monitor, therefore can be used to detect and control excessive moisture, etc. Capacitive primary element is sensitive to 0.1% dielectric constant variation.—*Instruments, Inc., Box 556, Tulsa, Okla.*

For more information circle **314** on inquiry card.

process measurement and control

PNEUMATIC CONTROLLER

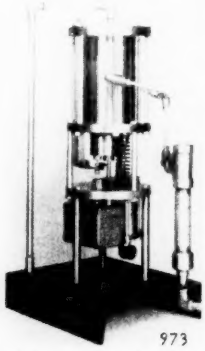
Newly improved Model 53-P motion-balance pneumatic controller has unique "regenerative feedback" cir-



cuit; handles pneumatic or mechanical signals by changing one subassembly. Complete selection of control modes.—*Fischer & Porter Co., 255 Jacksonville Rd., Hatboro, Penna.*

For more information circle **311** on inquiry card.

PIPE LINE VISCOMETER

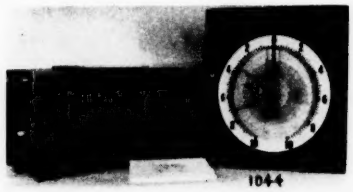


New Model M12 Viscometer Measuring Element, particularly suitable for petroleum and other similar applications, determines viscosity under actual pressure conditions of system; transmits electrically to Viscometer Recorder. Provision is made for measuring temperature and pneumatic temperature compensation is readily obtained. A heat exchanger can be installed in side stream.—*Norcross Corp., Dept. N45, Newton 58, Mass.*

For more information circle **313** on inquiry card.

AUTOMATIC RECORDING REFLECTOMETER

New Model 342-AR measures factors affecting color of materials on a production-line or moving web; en-



ables operator to adjust amount of dye, filler, etc.; conforms to ASTM and TAPPI; comes complete (with UX-2a Exposure Head not shown in photo) ready to install on production machine.—*Gardner Lab., Inc., P. O. Box 5728, Bethesda 14, Md.*

For more information circle **315** on inquiry card.

CONDUCTIVITY CELL

New in-line conductivity cell operates efficiently at temperatures up to 400°F with temperature compensation

and up to 1000°F when not using temperature compensation.—*Instrument Div., Robertshaw-Fulton Controls Co., 2920 N. 4th St., Philadelphia 33, Pa.*

For more information circle **312** on inquiry card.

ELECTRIC CONTROL UNITS

New Electr-O-Line (illustrated), Electr-O-Pulse and Electr-O-Volt electric control units incorporate replaceable printed circuits, continuously-adjustable proportioning reset and rate action, and silicon diodes for power supply. Each comprises three sections mounted in a die-cast aluminum chassis. Amplifier and power supply sections are the same for all. Control output section differs in each, but conversion from one controller to another is accomplished by plug-in of desired output section.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **316** on inquiry card.

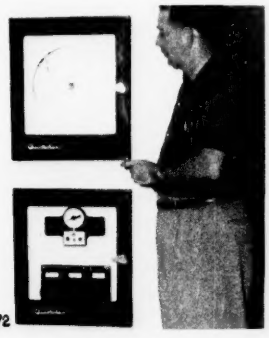
ARGON PURITY ANALYZER

New model of Argon Purity Analyzer has a range of 99.95% to 100%; measures continuously by means of thermal conductivity method; features new flow system and electric circuit whereby a change in analysis is shown in about 45 seconds.—*Thermco Laboratories, Michigan City, Ind.*

For more information circle **317** on inquiry card.

COLORIMETRIC ANALYZERS

New Quantichem automatic analyzers continuously analyze water for total hardness or silica concentration; may include alarms or control devices.—*Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.*



For more information circle **318** on inquiry card.

DENSITY MEASURING SYSTEM

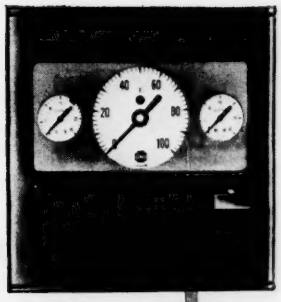
New Model P-625 continuously measures density of liquids in transit, storage, or throughout a reaction's cycle; can be used to proportion constituents, control reactions, etc.; indicates liquid density change of 0.01 g/cc in about 1 sec.—*General Communication Co., 681 Beacon St., Boston 15, Mass.*

For more information circle **319** on inquiry card.

FLUE-GAS ANALYZER

New mobile rack-mounted flue gas O_2 analyzer recorder for on-the-spot boiler and furnace test work to help

From TRANSMITTER to RECEIVER GAUGE



unequalled USG sensitivity-dependability

There's never a question as to the accuracy of temperature or pressure readings when transmitted by USG Pneumatic Transmitters.

And for accurate reception of signals from remote points, there's nothing to match the sensitivity of the new USG Receiver Gauge.

Consider these features:

USG PNEUMATIC TRANSMITTERS

- Sensitivity—Within 0.1% of full scale.
- Accuracy—1% (indicating) or ½% (non-indicating)
- Designed to operate at remote points for long periods without attention. High sensitivity, linearity and freedom from dead spot assure the ultimate in control stability.

USG PNEUMATIC RECEIVER GAUGES

- Sensitivity—Within 1/10 of 1% of full scale.
- Accuracy—± ¼ of 1% of full scale.
- Diaphragms made of Ni-Span "C", a special high nickel alloy with a minimum thermal shift, even under wide variations in ambient temperature.
- Available in 3½", 4½", 6" and 8½" sizes.
- Also available are 2", 2½" and 3½" Bourdon tube actuated type receiver gauges.

USG Transmitters and Receiver Gauges are part of USG's line of creatively engineered process control instruments. The line includes gauges, pressure and temperature pilots, recorders and controllers. Write for catalogs.

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For more information circle **71** on inquiry card.

Do the controls you specify carry these listings?

MERCOID PRESSURE AND TEMPERATURE CONTROLS

MERCOID TYPES DAE AND DSE
FOR HAZARDOUS LOCATIONS
N. E. CODE
Class I, Group D (NEMA 7)
Class II, Group E, F, G (NEMA 9, 9A)

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MERCOID TYPES DA AND DS
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EQUIPPED WITH SEALED MERCURY CONTACT SWITCHES

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THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

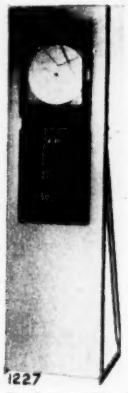
For more information circle **72** on inquiry card.

NEW INSTRUMENTS

improve combustion efficiency, operates in ambient temperatures between 32°F and 120°F, and from any standard non-regulated 115-v 60-cps power source; comprises a Magnetic O_2 Analyzer, a Speedomax G Recorder (round-chart or strip-chart), a vacuum pump and a full-flow sample filter.—*Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.*

For more information circle **320** on inquiry card.

CHLORINE ANALYZER

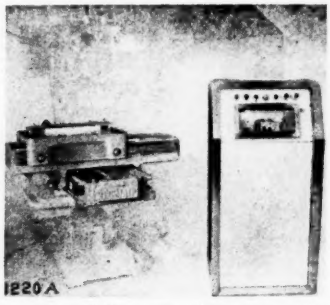


New Model 17A1100 continuously measures free, combined, or total residual chlorine in water or sewage; is accurate within 1% of maximum range; is essentially a double light beam filter photometer. Use of a split beam eliminates any effect that color or turbidity of the chlorinated sample might have. Two standard ranges: 0 to 1 or 0 to 10 ppm; other intermediate ranges available.—*Fischer & Porter, 495 Jacksonville Rd., Hatboro, Pa.*

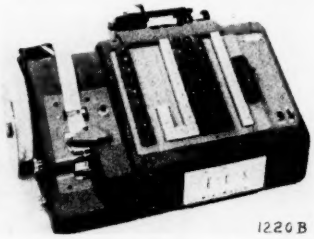
For more information circle **321** on inquiry card.

AUTOMATIC CONTROL FOR DRILL PRESSES, ETC.

New Digimatic Model C-202 Point Positioner enables one drill press to do the work of five; can be adapted



to spot welding, riveting, engraving, tapping, etc.; can also provide for nine auxiliary on-off functions such

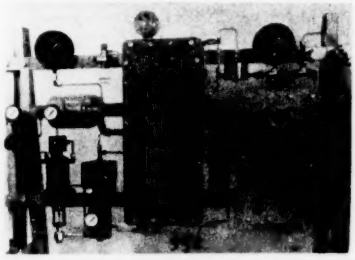


as magnetic clamping and unclamping, and turning on coolant.—*Electronic Control Systems, Inc., 2136 Westwood Blvd., Los Angeles 25, Calif.*

For more information circle **322** on inquiry card.

VAPOR PRESSURE RECORDERS

New Continuous Vapor Pressure Recorders have been developed by the Shell Development Co. Model 1157



(illustrated) is for use on gasolines and other low-pressure hydrocarbons; Model 1158 is for higher pressures and binary mixtures. Both incorporate test circuits for start-up and checking while on stream. Output is 3-15-psi pneumatic signal.—*Hallikainen Instruments, 1341 Seventh St., Berkeley 10, Calif.*

For more information circle **323** on inquiry card.

DUPLEX RECORDER

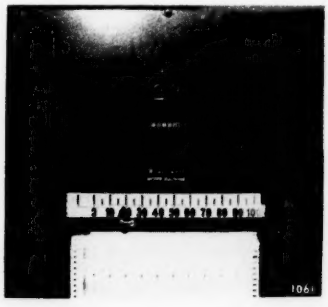
New Twin Recorder comprises two Type CH recorder chart carriages and measuring elements in a single

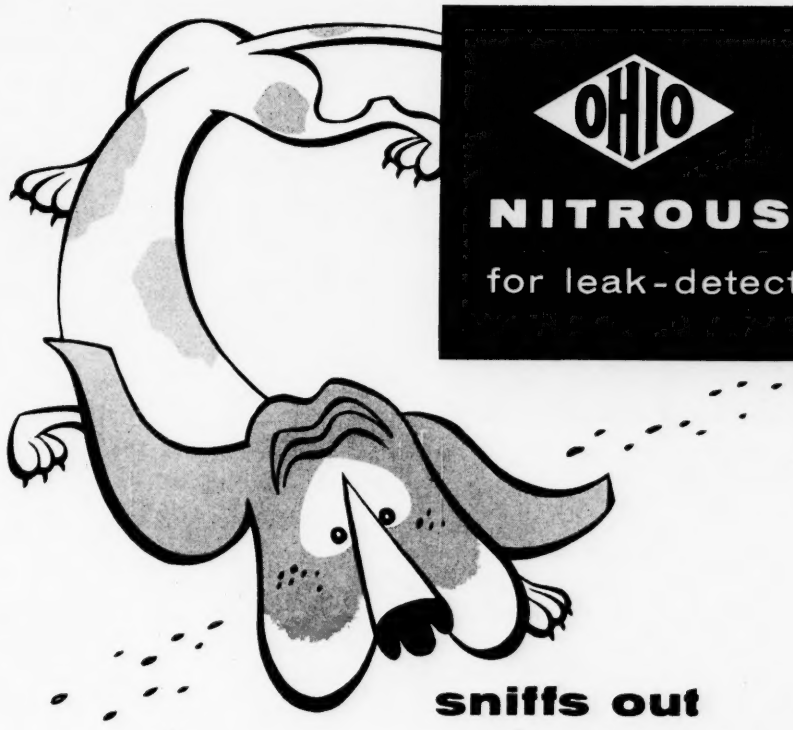
case that can mount on a 19" relay rack; embodies all design features of CH recorder line: 28 chart speeds, large "throwaway" plastic inkwell, 150-ft-long record rolls, etc.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **324** on inquiry card.

CONTINUOUS INTEGRATOR

New continuous integrator enables records of variables such as temperature, flow, pressure, kilowatts and





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NITROUS OXIDE

for leak-detection devices

sniffs out microscopic leaks!

OHIO NITROUS OXIDE

- Odorless and Inert
- Nontoxic
- Noncorrosive
- Nonflammable
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- Will not contaminate test pieces

FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection on pressure vessels, piping systems, auto suspension systems, or in any other problem concerning leak detection. For further written information, please write Dept. IA-1 requesting the following bulletins:

1A Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests.

1B Gas Service Equipment for Nitrous Oxide Supply.

Infrared determination of nitrous oxide gives you a highly sensitive, clean and flexible method of leak detection when used for test pieces of many sizes, and for large and small quantities. Just a few parts of nitrous oxide can be detected in a million parts of air.

Audible or visual warning devices may be used. This method is insensitive to usual atmosphere components, such as moisture, carbon dioxide and hydrocarbons.

Nitrous oxide offers you top efficiency, and does so at an exceptionally low cost when compared to other gaseous agents.

Ohio, the world's largest producer, assures you of nationwide availability of nitrous oxide through its 32 branch offices and over 70 warehouse points.

"Service is Ohio Chemical's Most Important Commodity!"

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At the frontiers of progress you'll find **An Air Reduction Product** . . . **Ohio**: Medical Gases and hospital equipment • **Airco**: Industrial gases, welding and cutting equipment, and acetylenic chemicals • **Pureco**: Carbon dioxide, liquid solid ("Dry Ice") • **National Carbide**: Pipeline acetylene and calcium carbide • **Colton Chemical**: Polyvinyl acetates, alcohols and other resins

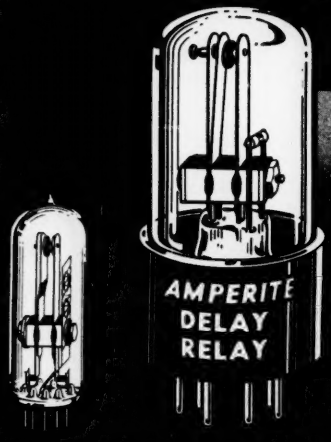
For more information circle **73** on inquiry card.

AMPERITE PREFERRED

by design engineers—because they're

MOST COMPACT • SIMPLEST • MOST ECONOMICAL

HERMETICALLY SEALED



Thermostatic DELAY RELAYS

2 to 180 Seconds

Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

Hermetically sealed. Not affected by altitude, moisture, or climate changes.

SPST only—normally open or closed.

Compensated for ambient temperature changes from —55 to + 70 C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived,** and—**inexpensive!**

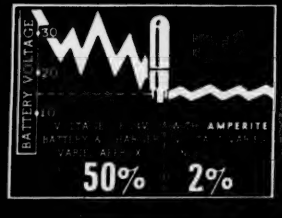
Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection

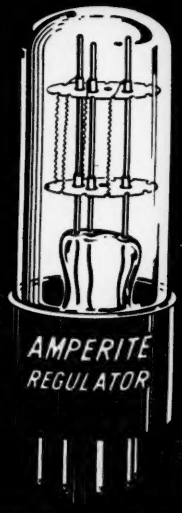
TYPES: Standard Radio Octal, and 9-Pin Miniature. **List Price, $4.00.** Standard Delays

PROBLEM? Send for Bulletin No. TR-81

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C., D.C., or Pulsating Current.





Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—55 to + 90 C.), or humidity . . . Rugged, light, compact, most inexpensive . . . . . **List Price, $3.00.**

Write for 4-page Technical Bulletin No. AB-51

AMPERITE CO. Inc., 561 Broadway, New York 12, N. Y.

Telephone: CAnal 6-1446

In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

For more information circle **74** on inquiry card.

NEW INSTRUMENTS

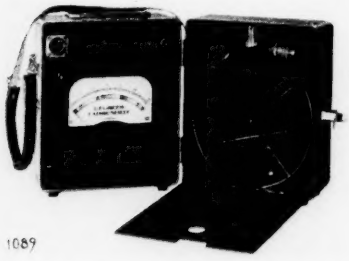
Btu's to be integrated on any strip or circular chart recorder whose transmitting slidewire has a linear output and a resistance between 20 and 250 ohms. It can be added to a recorder regardless of control features. Full-scale count rate is continuously adjustable up to 500 per minute when a pipping pen is used or 1000 per minute otherwise.—*Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Philadelphia 44, Pa.*

For more information circle **325** on inquiry card.

temperature

RESISTANCE THERMOMETER

New Model 917 Portable Resistance Thermometer, approved by Underwriters Laboratories for use in haz-



ardous locations, provides a quick, accurate means of securing spot temperatures of petroleum products, chemicals and other fluids in barges, tankers, etc.—*Weston Electrical Instrument Corp., Newark 12, N. J.*

For more information circle **326** on inquiry card.

MULTIPAIR THERMOCOUPLE EXTENSION CABLE

New multipair cables of Serv-Rite thermocouple extension wire are available with over-all polyvinyl plas-

tic sheath; can be hung without conduit, installed in an open trough, or buried.—*Claud S. Gordon Co., 3000 S. Wallace St., Chicago 16, Ill.*

For more information circle **327** on inquiry card.

TOTAL TEMPERATURE PROBE

New Model 49137 conforming to MIL-P-25726 utilizes a ceramic-blanketed resistive sensing element to accurately measure stagnation temperature from —70°C to 350°C and at speeds to Mach 1.5. Response time 1.5 sec max; recovery factor 0.99 ±0.01. —*G. M. Giannini & Co., 918 E. Green St., Pasadena 1, Calif.*

For more information circle **328** on inquiry card.

Investigate
ADVANTAGES
of the New
MASSA
ELECTRODYNAMIC
RECORDER

TRUE RECTILINEAR MOTION
CRITICAL ACOUSTIC DAMPING
WIDER FREQUENCY RANGE
INK OR ELECTRIC WRITING

FEATURES

LIGHTWEIGHT ELECTRODYNAMIC DRIVE for true rectilinear recordings free of distortions.

CRITICAL ACOUSTIC DAMPING eliminates resonant peaks overshoot and ringing.

WIDER FREQUENCY RANGE reproduces signals up to 200 cps.

MICROMETER ADJUSTING SCREWS conveniently located for accurate pen alignment.

DECIMAL SPEED CHANGER with 3 speeds. Max. — 200 mm/sec.

DISPOSABLE INK CARTRIDGE hermetically sealed prevents evaporation and maintains correct ink viscosity.

NEW PEN DESIGN with mechanical filter permits splatter-free writing at all frequencies.

WEIGHT 9 lbs. — Dimensions 13" L x 4⅜" W x 4½" H.

Also available is the Massa Model M-220 DUAL CHANNEL DC AMPLIFIER with self-contained power supply. Sensitivity range is 5mV/mm to 200 volts full scale with compensation to yield flat response from dc to 200 cps.

Write to Dept. 13 for technical data

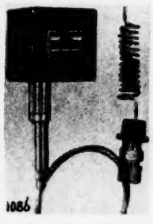
Other Massa Products for Industry:
SONAR TRANSDUCERS
ACCELEROMETERS
MICROPHONES
HYDROPHONES
ULTRASONIC CLEANERS
PREAMPLIFIERS
AMPLIFIERS
RECORDERS

precision in ML *electroacoustics*

MASSA
LABORATORIES, INC.
HINGHAM, MASSACHUSETTS

For more information circle **75** on inquiry card.

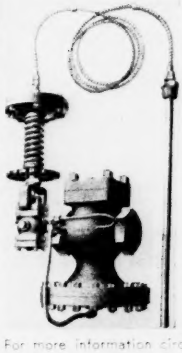
TEMPERATURE CONTROLLER



New Type F7 for ovens, water baths, incubators, air conditioning units, etc., operates snap-acting switch at preset temperature. Models have adjustable ranges between −150°F and 650°F and on-off differentials of 1 F° to 2 F°.—*United Electric Controls Co., 79 School St., Watertown, Mass.*

For more information circle **329** on inquiry card.

TEMPERATURE CONTROLLER

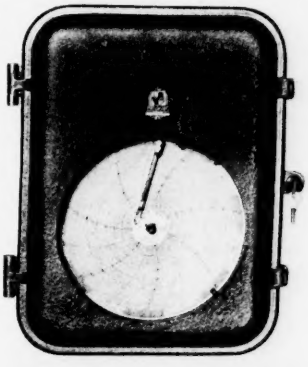


New temperature regulator comprises Type E main valve controlled by new T14 pilot which is recommended for slow-heating units such as plating tanks, kilns and ovens. —*Spence Engineering Co., Inc., Walden, N. Y.*

For more information circle **330** on inquiry card.

RECORDING THERMOMETER

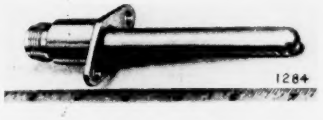
New Model TRW for recording oil temperature is designed for all-weather operation and has lock. Electric or spring-drive 24- and 48-hour or 7-day charts.—*The Partlow Corp., 503 Campion Rd., New Hartford, N. Y.*



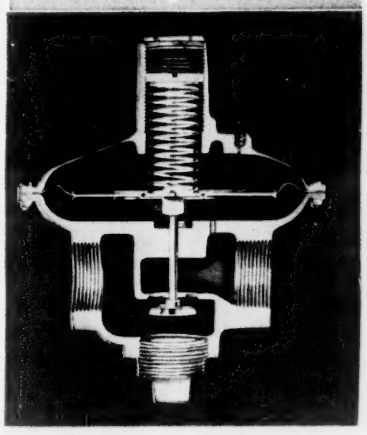
For more information circle **331** on inquiry card.

HIGH-VELOCITY-STREAM TC

New high-temperature thermocouple assembly, for use in the high-velocity gas streams of jet engine afterburners and ramjet and rocket ex-



WHAT'S INSIDE MAKES A BIG DIFFERENCE



Regulators and Controls are as good as the diaphragms actuating them.

Vulcan diaphragms have been accepted and depended on for almost 25 years.

Low gauges are available with excellent flexibility for delicate applications. Heavy gauges with high strength for rugged service are available in many coating compound types.

Vulcan provides integrated research, development and manufacturing facilities. This means complete quality control from raw material to finished product; assuring you that every diaphragm is made to strict specifications.

A vital part of this Vulcan integration is our research and development laboratory. If you have a diaphragm problem, we shall be happy to consult with you.

Another
REEVES VULCAN
RUBBER PRODUCT

***Write to:* Dept. 1-1**
REEVES BROTHERS INC.
Vulcan Rubber Products Division
54 Worth Street • New York 13, N.Y.

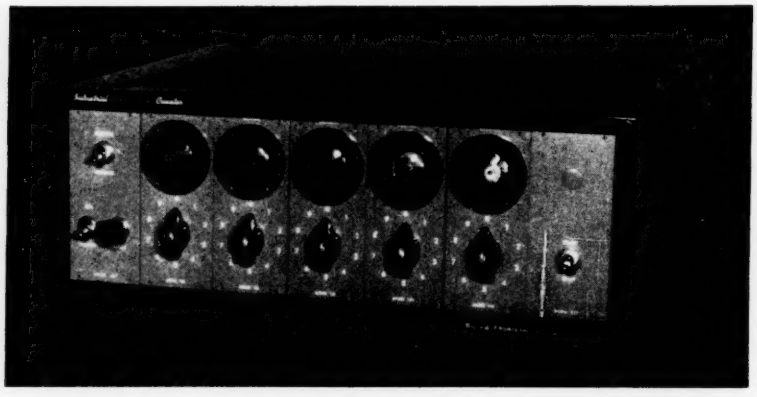
For more information circle **76** on inquiry card.

INSTRUMENTATION FOR BETTER ANALYSIS

SUPER-FAST, HIGH PRECISION

INDUSTRIAL COUNTING and CONTROL

WITH BAIRD-ATOMIC
ELECTRONIC COUNTING INSTRUMENTS



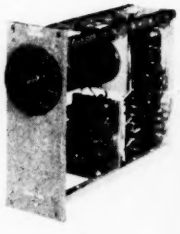
Many standard and special models available for counting, sorting, machine cycle, unit flow, packaging and other industrial and control applications.

Electronic speed and accuracy with up to 20,000 unit counts per second. DEKATRON* cold-cathode glow transfer tubes give constant visual reference to total count.

DEKATRON* TUBES AVAILABLE SEPARATELY

The DEKATRON cold-cathode glow transfer counting tube used in B-A instruments requires far less power than "hot" tubes. DEKATRON tubes permit simplified circuitry with fewer components than ordinary tubes resulting in greatly increased reliability. The moving glow spot within the tube indicates total and eliminates the need for additional indicating lights. Baird-Atomic is the sole distributor of DEKATRON tubes in the United States and Canada.

COMPLETE PLUG-IN STRIPS FOR CUSTOMER ASSEMBLY



Unitized plug-in strips with DEKATRON tube, numbered bezel and drive circuitry are available in many functional types. These B-A plug-in strips save assembly time and permit the customer to more easily incorporate the counter into existing panels or equipment.

For additional information on industrial counting instruments, DEKATRON tubes and plug-in strips write to:

*Patented.

Baird-Atomic, Inc.

33 UNIVERSITY RD., CAMBRIDGE 38, MASS.

Baird Atomic

For more information circle **77** on inquiry card.

NEW INSTRUMENTS

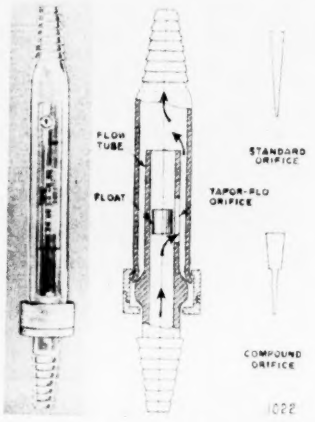
hausts, was designed to solve problems of probe life, accuracy, installation and maintenance at temperatures as high as 3600 F; utilizes cermet (ceramic-metal combination) support tube and radiation shield, obviating need of water or air cooling, eliminating conduction errors due to cooling, and reducing by about 60% radiation losses to cold duct walls.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

For more information circle **332** on inquiry card.

flow and volume

VARIABLE AREA FLOW METER

New MB Series all-glass Tapor-Flow features exceptional float stability which permits exact reading



without visual averaging. Standard flow tube sizes ¼" or ½" ID (special sizes or connections to order). Flow range depends on fluid specific gravity, flow tube size, and float weight. A special high-low version has a compound orifice.—*C-Mar Corp.*, 35 *Euclid Ave., Manasquan, N. J.*

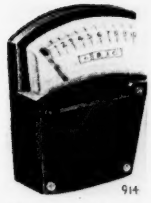
For more information circle **333** on inquiry card.

SLURRY FEEDER

New self-contained feeder for concentrated slurries can handle a 20%-by-weight slurry concentration of diatomaceous earth on a continuous basis. Feed rate is from 0.33 to 1.66 gpm of concentrated slurry. Unit will apply slurries against pressure up to 40 psi and vacuum down to 20" Hg.—*Wallace & Tiernan Inc.*, 25 *Main St., Belleville 9, N. J.*

For more information circle **334** on inquiry card.

AIR FLOW TESTERS



New FloRet Forced-Air Heating Balancer enables equalizing air flow from all warm-air registers for initial balancing adjustment, setting of blower speed and adjusting dampers. ★New Floret Air Circulation Tester is held in hand to check operation of mechanical air circulation system. Full scale pointer deflection represents air velocity of about 1000 fpm.—*Bacharach Industrial Instrument Co., 200 N. Braddock Ave., Pittsburgh 8, Pa.*

For more information circle **335** on inquiry card.

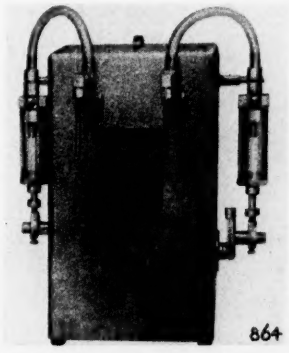
FLOW SWITCH

New Pottermeter Flow Switch is available in models to operate at any line pressure. Airborne 1" model weighs 12 oz and will indicate flows down to 0.1 gpm. All models can detect reverse flow and operate in any attitude in either liquid or gas; are available in flanged, screw fitting, flared tube, etc., in aluminum, stainless steel, bronze, nickel, Monel, Inconel, etc.—*Potter Aeronautical Corp., Route 22, Union, N. J.*

For more information circle **336** on inquiry card.

LIQUID FILLING MACHINE

New Filamatic Model DAB-8 filling machine dispenses from 0.002 oz to 16 oz of liquid per stroke at rates variable from 3 to 60 fills per minute. Vials can be filled singly, two at a time, or in multiples of two. For filling vials in multiples, machines are coupled by low-cost Synchronizer.—*National Instrument Co., 2701 Rockwood Ave., Baltimore 15, Md.*



For more information circle **337** on inquiry card.

Established 1847

QUALITY . . **OVER 100 YEARS** . . PROGRESS

Glass . . . ALL TYPES

PRECISION EXECUTION

For instrument dials and other industrial and technical uses

CLEAR COLORED SAFETY TEMPERED
HEAT RESISTING MALTESE NON-REFLECTING GLASS
INSTRUMENT LENSES PILOT LIGHT LENSES

Mirrors . . .

"EVABRITE" FIRST SURFACE MIRRORS — High reflecting hard metal coatings—direct reflection without parallax.

"EVALAST" Mirrors—silver backing protected by electroplating of copper—Eliminates deterioration through moisture, etc. Conforms to Government specifications.

We solicit your glass and mirror specifications for quotation

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636-638 GREENWICH ST. NEW YORK 14, N. Y.
For New York—WAtkins 4-2121
For New Jersey—MArket 4-5328

For more information circle **78** on inquiry card.

FOR...

Slip-On Insulation, Instrument Tubing, Bundle Sheathing, Medical Tubing, Pigtails...

USE PF SPAGHETTI SLEEVING

MADE FROM

TEFLON*

PF Spaghetti sleeving has these important advantages:

1. Good dielectric strength (500 to 2000 volts/mil)
2. Excellent electrical properties at high temperatures (500°F) and a wide frequency range
3. Low coefficient of friction. It slips on easily in long lengths of wire up to 3 ft.
4. Eliminates the need for silver coated wire
5. Zero moisture absorption
6. Unaffected by any commercial chemical
7. Stress relieved for negligible shrinkage

25 sizes, 2 wall thicknesses, 10 colors in stock, 100% inspected and controlled dimensionally are available.

Write, wire or call for full details, competent engineering assistance and information on special sizes and walls. PF Teflon* flexible tubing, heavy-walled tubing and rod stock are also available.

PENNSYLVANIA FLUOROCARBON CO., INC.

1115 N. 38th Street, Phila. 4, Pa. EVergreen 6-0603

*Teflon—DuPont trade name for Tetrafluoroethylene resin

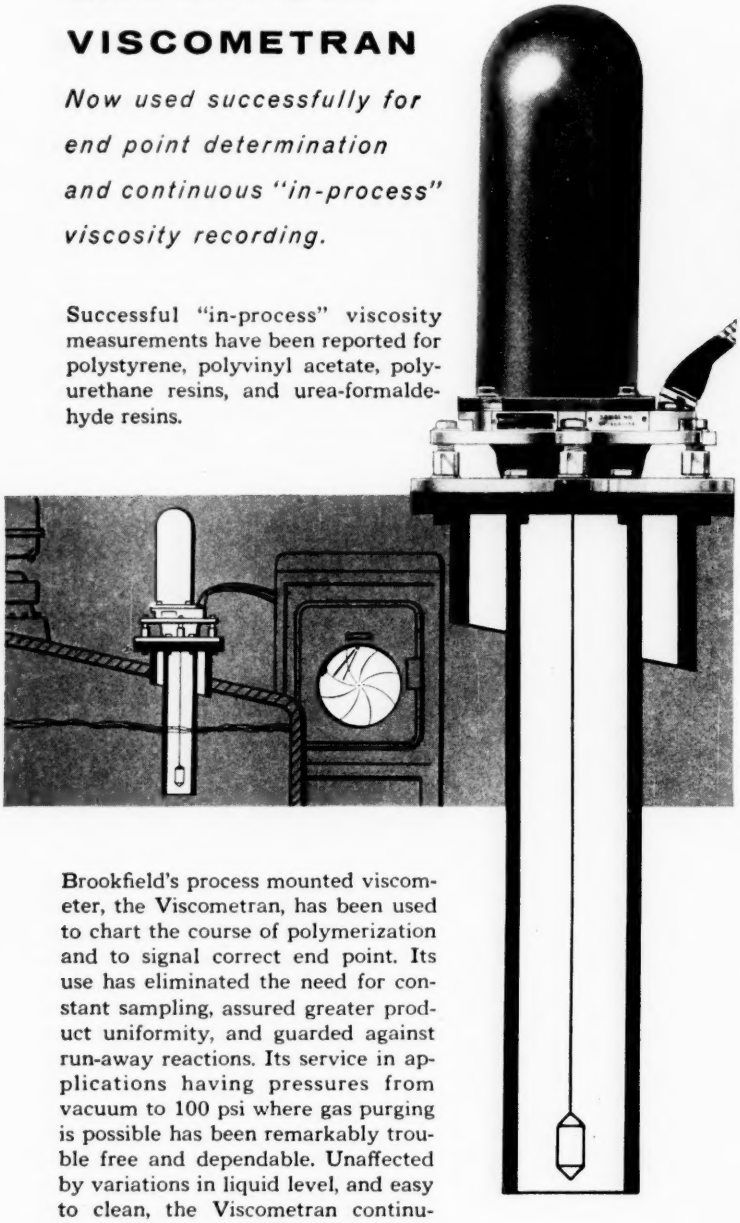
For more information circle **79** on inquiry card.

POLYMERIZATION NEWS!

BROOKFIELD VISCOMETRAN

Now used successfully for end point determination and continuous "in-process" viscosity recording.

Successful "in-process" viscosity measurements have been reported for polystyrene, polyvinyl acetate, polyurethane resins, and urea-formaldehyde resins.



Brookfield's process mounted viscometer, the Viscometran, has been used to chart the course of polymerization and to signal correct end point. Its use has eliminated the need for constant sampling, assured greater product uniformity, and guarded against run-away reactions. Its service in applications having pressures from vacuum to 100 psi where gas purging is possible has been remarkably trouble free and dependable. Unaffected by variations in liquid level, and easy to clean, the Viscometran continuously and accurately senses viscosity — a variable that can very well be fundamental in your process.

For new application data sheet write or wire:

Brookfield the world's standard for viscosity measurement

ENGINEERING LABORATORIES INCORPORATED

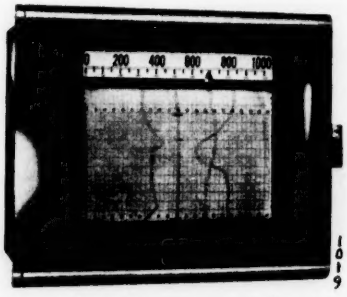
STOUGHTON 316, MASSACHUSETTS

For more information circle **80** on inquiry card.

telemetering

MULTIPLE-RECORD TELEMETER RECEIVER

New multiple-printing strip-chart Metameter telemeter receiver will print-out up to 16 records from as



many telemetering transmission centers; can monitor many pressures, flows, temperatures, etc.—*The Bristol Co., Waterbury 20, Conn.*

For more information circle **338** on inquiry card.

C C TRANSMITTER

New Type CT-50B fully transistorized carrier-current transmitter for utility industry supersedes Type CT-20; lowers maintenance costs by reducing need for frequent checking; is not merely a redesign to incorporate transistors but utilizes latest developments and circuit improvements.—*Communications Dept., General Electric Co., Electronics Park, Syracuse, N. Y.*

For more information circle **339** on inquiry card.

TELEMETERING & S-C SYSTEM

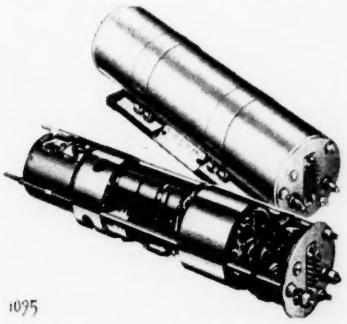
New industrial telemetering and supervisory control system uses one pair of wires (leased or private) for

both incoming data signals and outgoing supervisory commands; is particularly suited for continuous-process uses. Basic system can handle up to 165 on-off type controls or 17 telemetered analog signals, or combinations of both; features once-a-second self-checks.—*Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.*

For more information circle **340** on inquiry card.

VOLTAGE MONITOR

New Precision Voltage Monitor reduces normal telemetering and recording system errors from 4% or



1095

5% to 0.04% or less. It is a servomechanism which accepts analog signals from measurement pickups and provides output by voltage-dividing resistors, synchros, or coded discs.—*G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.*

For more information circle **341** on inquiry card.

acceleration

INERTIA SWITCH

New 1 SA 1 switch, actuated by thrusts, impacts or excessive vibrations, originally designed for aircraft and missile uses, protects unattended industrial fans, compressors, etc., against unusual vibrations and shuts off machine or sounds an alarm. Manual reset button is provided; electrical reset available. Force-of-actuation settings are factory adjusted: 1.5 to 10 *G* or more.—*Micro Switch, Freeport, Illinois.*

For more information circle **342** on inquiry card.

ACCELERATION PICKUP

New line of acceleration pickups covers a wide range of static or uniformly-varying type of accelerations.—*Fairchild Controls Corp., 225 Park Ave., Hicksville, N. Y.*

For more information circle **343** on inquiry card.

ACCELERATION SWITCH

New acceleration switch for missile and rocket fire control systems closes an electric circuit when it is

942

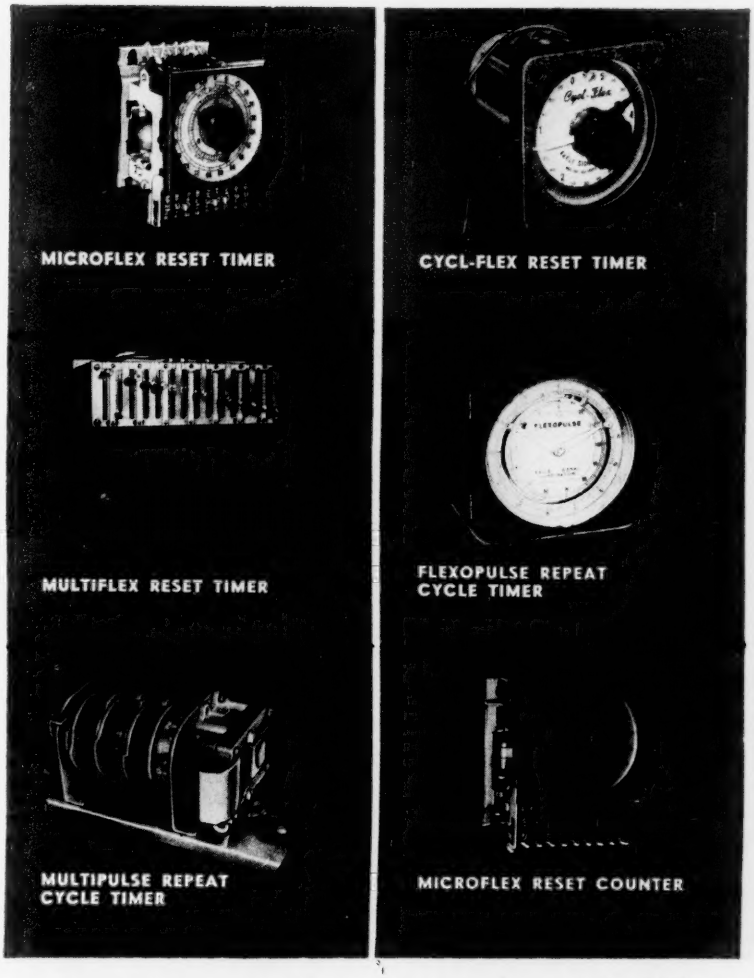
subjected to an acceleration from any direction in one plane; can be adjusted to respond to gentle-start steady-state accelerations or to shock loadings.—*ERA Engineering, Inc., 1009 Montana Ave., Santa Monica, Calif.*

For more information circle **344** on inquiry card.

EAGLE

Timers and Counters

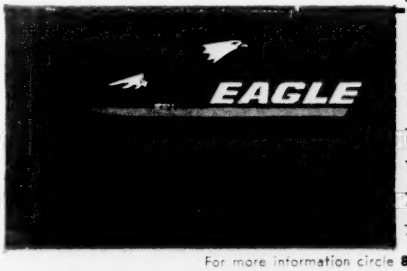
VITAL COMPONENTS IN MODERN AUTOMATION



Represented above are but a few of the complete line of popular EAGLE Industrial Timers and Counters.

Models are available in a wide range of modifications to fit your particular application. Modern compact design and precise construction of these EAGLE components has won them an enviable coast-to-coast reputation for accuracy and long service-free life of operation. Write us about your needs.

MAIL COUPON TODAY!



EAGLE SIGNAL CORPORATION
Industrial Division, Dept. IA-158,
MOLINE, ILLINOIS

Please send free circulars of the above Timers and Counters.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

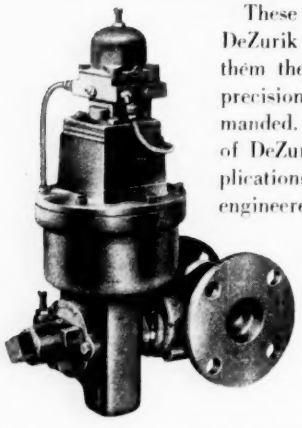
For more information circle **81** on inquiry card.

WHICH OF THESE FEATURES DO YOU WANT ON YOUR CONTROL VALVES?

Built-in Positioner
"O" Ring Piston
Totally enclosed Operator
Provision for manual operation
Straight-thru flow
Drip Tight Shut-off

THEY'RE ALL STANDARD ON
DeZurik
CONTROL VALVES

at low initial cost . . . .
. . . with low maintenance cost!



These and other features of DeZurik Control Valves make them the growing favorite where precision performance is demanded. The decided advantages of DeZurik Valves on control applications, and an air operator engineered to fully utilize those advantages, result in excellent control characteristics.

DeZurik Control Valves are avalable in sizes ½" thru 20", with on-off or positioning air or hydraulic operator, and in a full range of materials. Representatives in all principal cities, or write for more information to

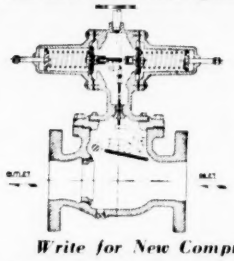
DeZURIK CORPORATION
SARTELL, MINNESOTA

For more information circle **82** on inquiry card.

For more information circle **83** on inquiry card.

THERE IS A *Security* AUTOMATIC SHUT-OFF VALVE FOR EVERY REQUIREMENT

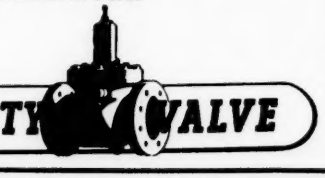
Security Valves will provide automatic shut-off in the event of increase in pressure, decrease in pressure, or on pressure differential. Solenoid controls for remote control furnished as required. May be actuated by direct line pressure or by static line control. Manual reset for oil, gas, or chemical service in accordance with API and ASME specs.



MODEL "IDPS-H" (closes on Increase OR Decrease in Pressure; Static line control; High pressure application). Described in detail in Bulletin 227-C.

Write for New Comprehensive Bulletin

SECURITY VALVE CORP.
541 W. GARFIELD, GLENDALE 4, CALIF.
CHAPMAN 5-5725



For more information circle **84** on inquiry card.

laboratory equipment

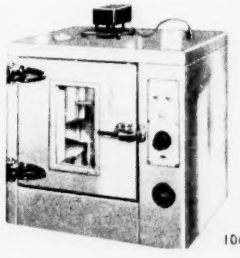
MEDICAL GAS ANALYZER

New Model LB-1 infrared analyzer measures concentrations of various gases of medical interest; is expected to be used in such work as pulmonary investigations, research on new anesthetics, and monitoring patients under anesthesia.—*Spinco Div., Beckman Instruments, Inc., Palo Alto, Calif.*

For more information circle **345** on inquiry card.

REVOLVING SHELF OVEN

New Model 5730 (ASTM D-6) features exclusive interval timer, is suitable for loss-on-heating of oil and



asphaltic compounds; has a large shelf with four 5½" pans.—*Nat'l Appliance Co., Portland 19, Oregon.*

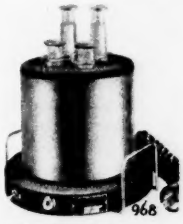
For more information circle **346** on inquiry card.

MONOCHROMATIC SOURCE

New Atomic Hydrogen Lamp is a new type of gas-discharge tube emitting sharp high-intensity H_α Balmer lines of great importance in refractometry, testing, etc. Available in 25- and 75-watt sizes, both featuring a line source 1 mm wide and 50 mm long. Both have electrical connections like those on instant-start fluorescent lamps.—*Robert K. Hassler Co., Post Office Box 177, Altadena, Calif.*

For more information circle **347** on inquiry card.

MOISTURE METER



New Model I Volatimeter determines moisture content of solids with greater speed than other methods presently available; uses a syringe method; measures volume of water vapor volatilized from particles of specimen just below melting point; comes complete with carrying case and accessories.—*Manufacturers Engineering & Equipment Corp., York Road & Sunset Lane, Hatboro, Pa.*

For more information circle **348** on inquiry card.

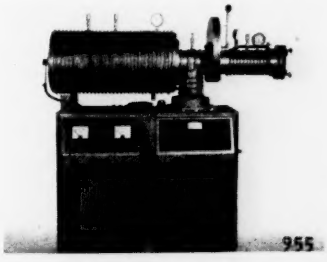
ULTRA-MAGNIFIER

New ultra-magnifier quadruples enlarging power of RCA's model EMU-3 electron microscope to more than one million times; is available in an install-it-yourself kit.—*Radio Corp. of America, 30 Rockefeller Plaza, New York 20, N. Y.*

For more information circle **349** on inquiry card.

VACUUM ANNEALING FURNACE

New Model F1212-2A, for lab or light production, easily converts to a melting furnace, so that user has a



complete installation for vacuum processing at a fraction of cost and space normally required. Can operate continuously at 2150°F or intermittently at 2200°F, at 0.1 micron Hg or less.—*High Vacuum Equipment Corp., 2 Churchill Rd., Hingham, Mass.*

For more information circle **350** on inquiry card.

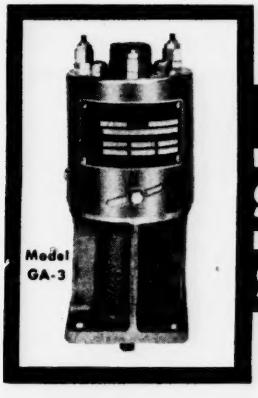
Measure any temperature from −200° F. to +600° F. with one instrument

Thermotest is the all-purpose testing instrument for precise measurement of temperatures from −200 F. to +600° F., and emf's up to 20.1 millivolts. It's the only portable potentiometer with interchangeable direct reading scales *and* automatic compensation. Measurements are read directly from the scale without charts, graphs or conversion tables. Scales interchangeable in seconds for use with three types of thermocouples. Mercury battery power supply. Leatherette covered case. Dimensions: 12¼" x 9" x 8½". Weight: 14 lbs. Write for free bulletin.

TECHNIQUE

TECHNIQUE ASSOCIATES, INC.
POST OFFICE BOX 91
INDIANAPOLIS 6, IND.

For more information circle **85** on inquiry card.



Synchro-Start SPEED SENSITIVE SWITCHES

SYNCHRO-START MODEL GA-3 will open or close three independent sets of contacts at three different speeds and are suitable for installation on AND20005 aircraft tachometer drive pad. The units are adjustable while running. Standard governors can be furnished to trip points between 1,200 and 6,000 R.P.M. Speeds above or below these points must be referred to our Engineering Department for special considerations.

These speed sensitive switches are available for various types of drives.

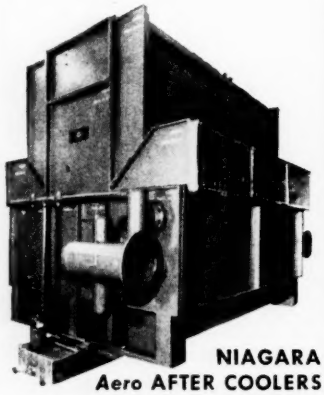
One, two, and three switch units employ the same basic governor flyweight principle which has been used successfully in SYNCHRO-START OVERSPEED GOVERNORS during the past fifteen years.

Request Bulletin 504

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVE. • SKOKIE, ILLINOIS

For more information circle 86 on inquiry card.

ECONOMICAL COOLING OF GASES and COMPRESSED AIR



NIAGARA
Aero AFTER COOLERS

● Cooling gases or cooling and removing moisture from compressed air, the Niagara *Aero* After Cooler offers the most economical and trustworthy method. Cooling by evaporation in a closed system, it brings the gas or compressed air to a point close to the ambient temperature, effectively preventing further condensation of moisture in the air lines. It is a self-contained system, independent of any large cooling water supply, solving the problems of water supply and disposal.

Cooling-water savings and power-cost savings in operation return your equipment costs in less than two years. New sectional design reduces the first cost, saves you much money in freight and installation labor and in the expense of upkeep.

Niagara *Aero* After Cooler systems have proven most successful in large plant power and process installations and in air and gas liquefaction applications.

Write for Descriptive Bulletin 130

NIAGARA BLOWER COMPANY

Dept. IN-1, 405 Lexington Ave.
NEW YORK 17, N. Y.
District Engineers in Principal Cities of U. S. and Canada

For more information circle **87** on inquiry card.

speed

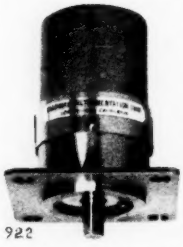
OPTICAL TACHOMETER

New Model 219 Multi-Probe, for use with any standard oscilloscope, obtains velocity and repetitive readings from otherwise inaccessible places without physical coupling; uses reflected light, optical paths and photocells; is battery-operated, has simple finger switch; comes with three sets of probe fittings in a compact Lucite box.—*OPTOmechanisms Incorporated, 216 E. 2nd St., Mineola, N. Y.*

976 "Light pipes"

For more information circle **351** on inquiry card.

TACHOMETER TRANSMITTER



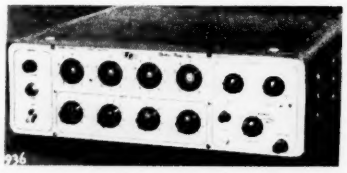
922

New tachometric pickup has a built-in frequency converter that provides in one miniature unit the necessary 0-5 vdc output for telemetering. Output of all models is adjustable and 5-v level can be set for any speed between 3,500 and 18,000 rpm. Meets MIL-E-5272A specs. Fast delivery.—*Cardinal Instrumentation Corp., Dept. TR2, 4201 Redwood Ave., Los Angeles 66, Calif.*

For more information circle **352** on inquiry card.

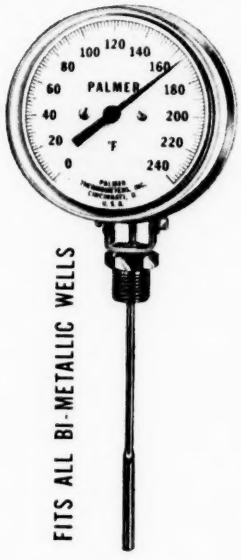
PRESET COUNTER & DIGITAL FREQUENCY DIVIDER

New 4-decade Model 7240B features fast recycle for such applications as batching and frequency division. Pickup outputs upon reaching preset count include a coincidence pulse for triggering other electronic equipment, an adjustable-width gate for actuating external equipment, and dp-dt relay. Controls are easily understood and operated by non-technical personnel.—*Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.*



For more information circle **353** on inquiry card.

Outstanding Accuracy
PALMER
Dial Thermometer



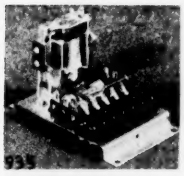
Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

PALMER
THERMOMETERS, INC.
Mfrs. of Industrial Laboratory, Recording and Dial Thermometers
2515 Norwood Ave., Cincinnati 12, O.

For more information circle **88** on inquiry card.

SPEED CONTROL RELAY

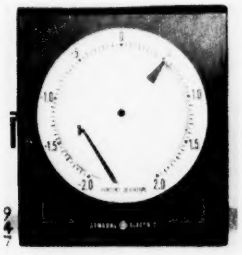


New Model 3420 operates as an over- or under-speed control, requires no external power source other than output of a power type magnetic pickup which acts as a miniature generator when placed near teeth of a rotating gear. Relay sp-dt contacts rated 5 amp non-inductive load.—*Electro Products Labs., Inc., 4500 N. Ravenswood Ave., Chicago 40, Ill.*

For more information circle **354** on inquiry card.

SPEED DEVIATION RECORDER

New Type HE speed deviation round-chart recorder with 0.1% ac-

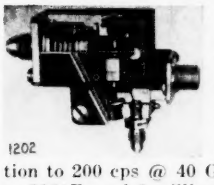


curacy is normally supplied with switches which initiate alarms when speed deviates from quality-control limits. Typical percent ranges: 1-0-1, 2-0-2, and 5-0-5.—*Instrument Dept., General Electric Co., West Lynn, Mass.*

For more information circle **355** on inquiry card.

pressure and vacuum

PRESSURE SWITCH

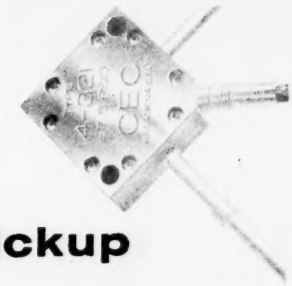


New explosion-proof AeroSwitch, originally developed for rocket industry, withstands vibration to 200 cps @ 40 G, temperatures to 300° F, and 8-million psi/sec surges to 4000 psi. Available in settings from 20 to 1000 psi. Burst pressure 8000 psi.—*Aerojet-General Corp., Azusa, Calif.*

For more information circle **356** on inquiry card.

PRESSURE SWITCHES

New pressure switches are available in materials suitable for use with acids and highly corrosive materials. Proof pressures to 6000 psi; pressure



a pressure pickup

smaller than a dime

withstands 200 G's

CEC's new miniature Type 4-320 Pressure Pickup operates at line pressures up to 300 psi . . . measures differential pressures in ranges from ± 7.5 psid to ± 50 psid, and gage pressures in the 25 psig and 50 psig ranges.
Ideal for airborne applications, the 4-320 features extremely small size (diaphragm diameter .475" x ¼" nominal thickness), light weight (4 grams), and ability to operate over a compensated temperature range of −65 to + 250 F.

Also available is the new Type 4-321 Pressure Pickup, which extends the applications of the 4-320 by providing it with a stainless-steel casing, one inch square and ⅜" thick. Although designed particularly for differential measurements, the 4-321 can be used for gage pressures by venting the reference inlet to atmospheric pressure. Write for Bulletin CEC 1579-X4.

Transducer Division CEC

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, Calif.

RECOGNIZED LEADERS IN GALVANOMETERS, TELEMETRY, PRESSURE AND VIBRATION INSTRUMENTATION

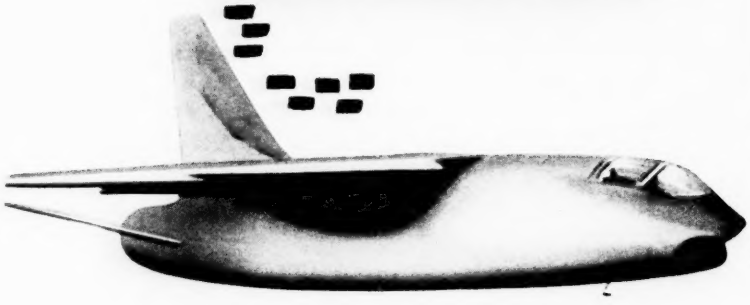
For more information circle **89** on inquiry card.

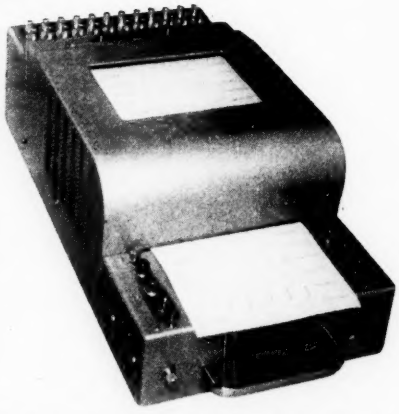
for quick look at telemetered signals jet fighter builder uses

Century

ELECTROGRAPH

MODEL 420





ELECTROGRAPHS installed in the ground station provide an immediate record of 24 simultaneous air-to-ground telemetered flight parameters. Progress of the flight test is followed with virtually no delay, thus minimizing costly reruns and permitting program changes during the test sequence. The Model 420 ELECTROGRAPH is the *ONLY* photographic recorder suitable for truly "quick-look" applications. High contrast records visible to the observer may be produced within ½-*second* after receipt of the excitation signal . . . NO other photographic oscillograph approaches this performance. When the "quick-look" must be quick, specify the ELECTROGRAPH.

As in flight test use, most "quick-look" applications require a high degree of record readability. The high contrast of ELECTROGRAPH recordings is *UNEXCELLED* with the result that record readability is maximum. The black traces and timing lines embossed on light-colored, non-glare emulsion offer the optimum condition for ease of data reduction.

For additional details on this 24-channel recording oscillograph, you are invited to write, wire or call for bulletin CGC-311.

Century Electronics & Instruments, Inc.

1333 No. Utica, Tulsa, Oklahoma

For more information circle **90** on inquiry card.

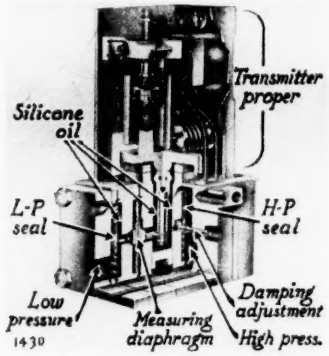
NEW INSTRUMENTS

settings from 2 to 4800 psi; operating temperature range −65°F to 275°F.—*Barksdale Valves, Pressure Switch Div., 5125 Alcoa Ave., Los Angeles 58, Calif.*

For more information circle **357** on inquiry card.

D/P TRANSMITTER

New force-balance Differential Pressure Transmitter features measuring circuit immersed in silicone oil,

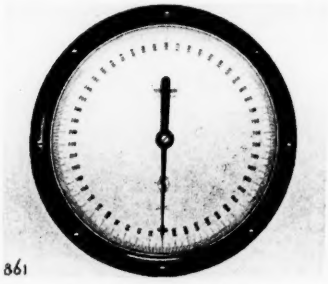


yet rapidly responsive to d/p changes. Working pressure limit 1500 psig; complete over-range protection; exceptional stability.—*Fischer & Porter Co., 457 Jacksonville Rd., Hatboro, Penna.*

For more information circle **358** on inquiry card.

TEST GAGES

New precision test gages feature improved manufacture of Bourdon tube which, with advanced design

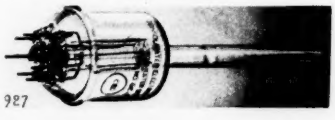


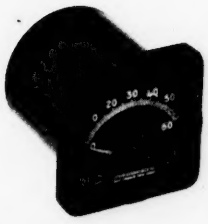
movement, makes possible 360° calibration. Guaranteed production calibration 0.15% full-scale accuracy. Flush, wall or stem mount. Ranges from 60 to 15,000 psi.—*Martin-Decker Corp., 3431 Cherry Ave., Long Beach 7, Calif.*

For more information circle **359** on inquiry card.

VACUUM GAGE TUBE

New Type GIC-001 Bayard-Alpert type of vacuum ionization tube, operable from any control circuit, in-





COLVIN 438 PRESSURE TRANSDUCERS

Available in 5 standard pressure ranges to 160 PSI. Vacuum and compound ranges are also standard.

The 438 is engineered for industrial and laboratory application in remote pressure reading, recording and control. It can be furnished singly or with a matched indicator.

Write for Bulletin 438 for further detail.

COLVIN LABORATORIES, INC.
364 Glenwood Avenue, East Orange, N. J.

For more information circle **91** on inquiry card.

JEWELS *for* INDUSTRY. . .

By MOSER JEWEL COMPANY, pioneer industrial jewel manufacturer for over 50 years.

- HIGHLY POLISHED STEEL PIVOTS AND STAFFS
- HARD ALLOY WELDED TIPS
- NON-MAGNETIC STAFFS
- DIAMOND POINTS

FOR INFORMATION ON HOW WE MAY FILL YOUR REQUIREMENTS

Write to . . .

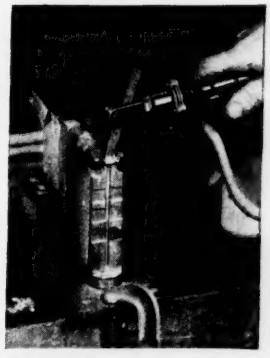
MOSER JEWEL COMPANY
P.O. Box 150 • Perth Amboy, N. J.

"Manufacturers of all types of Industrial Jewels"

For more information circle **92** on inquiry card.

Resistance Heat Soldering Ends "Cold Flow" Rejects-- Insures Strong, Uniform Joints

In an increasing number of plants, resistance heat soldering has practically licked the problem of non-uniform solder joints and "solder voids."



Resistance heat soldering of parts with preformed soldering rings, using "Pencil" attachment, and jig set-up.

The resistance heating principle makes cold flow joints all but impossible. High amperage, low voltage current, passing *through* the joint to be soldered, heats the joint above the temperature required to melt the solder. Heat is concentrated at the point of contact to prevent burning of nearby parts. No set-up or pre-heating is necessary. Solder adheres instantly and uniformly over and between the surfaces to be joined, to make the strongest joint it is possible to make. Heat is adjustable by thumb switch and instantly controlled to meet job requirements.

For the Most Complete Information Available on Resistance Heat Soldering, Send for Data on

IDEAL THERMO-GRIP SOLDERING SETS

Used for more resistance heat soldering than any other type. Complete details on all models, from the 450-watt light duty model up to the 7500-watt unit for large brazing jobs. Also application data on various attachments, including "grip-and-heat" "Pliers", "Fork" and "Pencil" attachments. All units are fully portable.

PROVED BETTER FOR JOBS LIKE THESE:

- Hermetic closures
- Tube joints
- Bellows and diaphragms
- Bourdon tubes
- Wherever strong, vibration-proof or air-tight seals are required.

SOLD THROUGH AMERICA'S LEADING DISTRIBUTORS
In Canada: Irving Smith, Ltd., Montreal

GET FULL DATA FREE

IDEAL INDUSTRIES, Inc.
1420-A Park Avenue, Sycamore, Illinois

Please send full information and technical data on IDEAL Thermo-Grip Soldering and Brazing Equipment.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

For more information circle **93** on inquiry card.

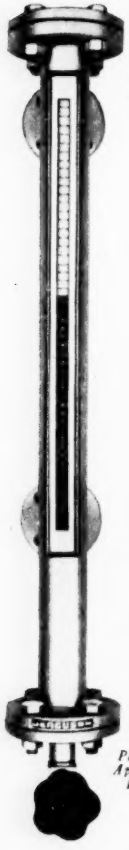
Announcing

the New

Jerguson

MAGNETIC GAGE

For Liquid Levels



An important advancement in liquid level observation for plants with dangerous explosive or inflammable conditions.

Safety design seals against escaping gases.

Measuring mechanism in stainless steel chamber.

Scale mounted outside chamber; magnetically actuated through chamber wall.

Distinct, accurate level shown in red contrasted with silver above.

Job designed, correlating pressure, temperature, and specific gravity.

For pressures up to 2500 lbs. @ 600° F.

Patent Applied For

Can also be used for interface indication.

Write now for engineering sheet on Jerguson Magnetic Gages.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Adams Street, Burlington, Mass.

Offices in Major Cities

In Canada: Peacock Bros. Ltd.

For more information circle **94** on inquiry card.

NEW INSTRUMENTS

dicates ultra-low pressures (in 10^{-12} mm Hg region) and at the same time possesses excellent sensitivity (100 microamperes per micron); has a double filament for longer tube life, and its grid can be outgassed easily by electron bombardment.—*Consolidated Electrodynamics Corp., Rochester Div., 1775 Mt. Read Blvd., Rochester 3, N. Y.*

For more information circle **360** on inquiry card.

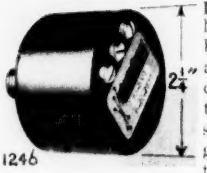
PRESSURE PICKUP

New P900 variable-inductance type pressure pickup features high-level dc output, infinite resolution, high frequency response, and resistance to shock and vibration; is believed to be "the only instrument of its type currently being marketed."—*Datran Electronics, 3615 Aviation Blvd., Manhattan Beach, Calif.*

For more information circle **361** on inquiry card.

PRESSURE TRANSMITTER

New Series 70-2000 Compu-Tran yields output in the form of precision resistance proportional to input



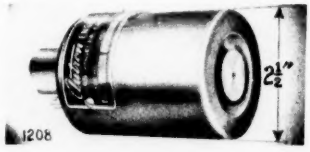
pressure. High-level signals can be used without amplification in control, telemetering, etc. Five standard ranges, from 0-15 to 0-200 psig.—*International Resistance Co., Computer Components Div., 401 N. Broad St., Philadelphia 8, Pa.*

For more information circle **362** on inquiry card.

displacement

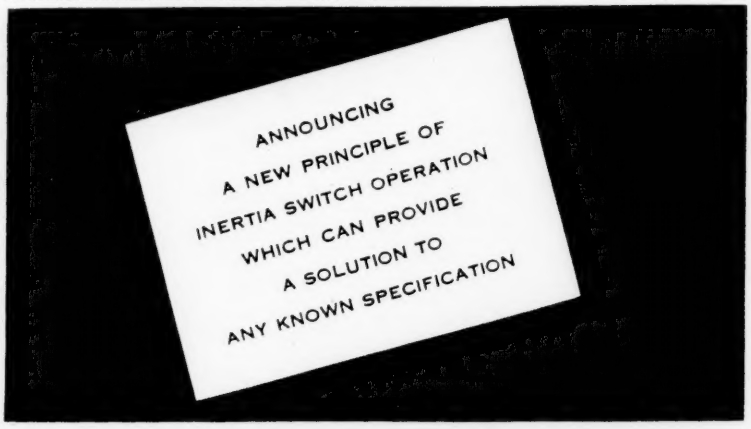
PROXIMITY DETECTOR

New Model 6120 Proximity Detector responds to presence of all metallic and most non-metallic materials.



Within limits, it will detect a $\frac{1}{16}$" change of position of metallic parts. It can be used for process control in conjunction with maker's Model 6330 Controller. Response rate 400 ppm; output nominally 5 vdc across a 5-megohm load.—*Autron Engineering Inc., 1254 W. Sixth St., Los Angeles 17, Calif.*

For more information circle **363** on inquiry card.



Standard or special designs proven and in use furnish — unique reliability due to a single moving part • all directional characteristics • millisecond to extended seconds response time • smallest volume • lightest weight • open or closed contacts • relay or automatic operation • meets environmental MIL SPECS • substantially lower cost.

For a prompt and reliable answer to your requirements telephone Plaza 5-1583 or write Department 422.

Inertia Switch

division of SAFE LIGHTING, Inc.

527 Lexington Ave., N. Y. 17, N. Y.

For more information circle **95** on inquiry card.

DISPLACEMENT PICKUP

New Atcotran Differential Transformer withstands severe humidity, salt-spray, vibration and altitude

tests; has output of 2.9 mv per 0.001" displacement per volt input at 400 cps; linearity better than 1%; range ±0.175"; length 2¼"; cadmium-plated armature has threaded ends with torpedo-shaped head at one end and actuating rod at other end.—*Automatic Timing & Controls, Inc., King of Prussia, Penna.*

For more information circle **364** on inquiry card.

DISPLACEMENT PICKUP

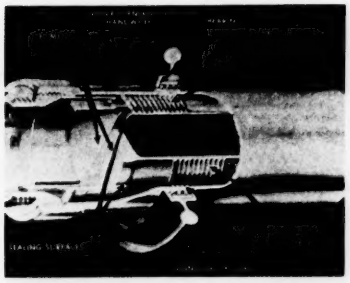
New Type 3050XS-AT Linear Variable Differential Transformer (LVDT) has an output voltage which

is a precise linear function of core displacement over a linear range of more than ±3". At 3" displacement, output for nominal 26-v 400-cps input into a 0.5-megohm load is 6 v. Output variation is stepless; effective resolution depends entirely on voltage or current sensitivity of associated equipment.—*Schaevitz Engineering, P. O. Box 505, Camden 1, N. J.*

For more information circle **365** on inquiry card.

MOTION TRANSMISSION

New Harmonic Drive employs controlled waves of deflection in solid steel walls of vessels, pipes, etc., to



drive mechanisms within those walls, obviating need for valve stems or other parts passing through wall. Illustration shows a hermetically-sealed valve with all rotating parts outside valve. Sealed within valve are only two moving parts: valve closure segments. Positioning of these parts by external motor drive is through surfaces in almost pure rolling contact. Position indication is positive. —*United Shoe Machine Corp., 140 Federal St., Boston, Mass.*

For more information circle **366** on inquiry card.

SV-4900 multi-purpose solenoid valve

The valve that outlasts the equipment!

- ✻ **New, unique plunger seal design**
- Soft rubber seal assures bubble-tight sealing.
- Completely dependable for millions of cycles.
- Full operation in **any** position.
- Stainless steel internal construction, brass body.
- Easy to disassemble and clean.
- Smaller... Lighter.

Last longer than other valves... yet only $6.50 list.

ANOTHER VALCOR ENGINEERING EXCLUSIVE

VALCOR SV-4900 series...2.35" high by 1.50" wide...available 7/64 orifice rating 130 PSI max. and 5/32 rated 60 PSI max. ...for use with water, air, steam, inert gases, petroleum and vegetable oils, gasoline, kerosene and many other semi-corrosive media...and they are stocked for off-the-shelf delivery.

WRITE for VALCOR Catalog 105, plus information on the many VALCOR valves available.

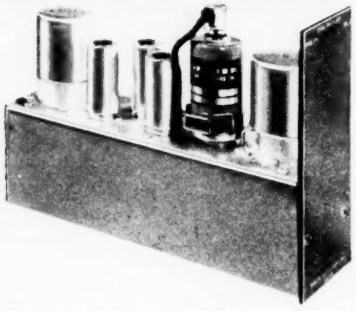
VALCOR ENGINEERING CORP.
5366 CARNEGIE AVE.
KENILWORTH, N. J.

VALCOR SOLENOID VALVES

For more information circle **96** on inquiry card.

THE OFFNER TYPE 190

DIFFERENTIAL DATA AMPLIFIER

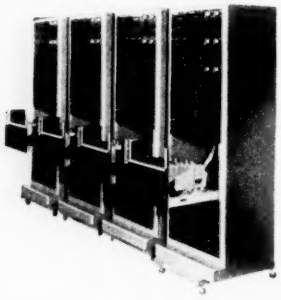


For amplification of thermocouple, strain gage, and similar low level signals the Type 190 Data Amplifier provides a combination of features available in no other amplifier:

- ☆ **Infinite rejection of common-mode d-c signals**
- ☆ **One microvolt input resolution**
- ☆ **Gain stability of 0.01%**
- ☆ **Rapid step input response**
- ☆ **Linearity of 0.05%**

Ask for bulletin No. 572 giving full technical information

OFFNER DYNOGRAPH
Direct-Writing Oscillograph



Zero-drift d-c recorder with microvolt sensitivity. One amplifier type covers all requirements.
Models for one to 19 channels.
Rectilinear or Curvilinear recording.

Ask for bulletin No. L-861

OFFNER ELECTRONICS
5326 N. Kedzie Avenue
Chicago 25, U.S.A.

For more information circle **97** on inquiry card.

photoelectric equipment

PHOTOELECTRIC CONTROLS

New miniaturized Electric Eyes can be mounted "in hitherto impossible spaces"; can operate when a direct light beam is cut by a passing object, or on light reflected from a surface. Both lead sulfide and cadmium sulfide photocells are available, as are various circuits involving delays in action, pulse monitoring, etc.—*Ess Instrument Co., 96 S. Washington Ave., Bergenfield, N. J.*

For more information circle **367** on inquiry card.

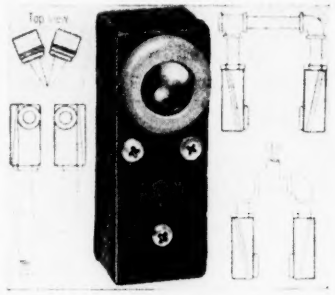
ANTI-INTRUSION SYSTEM

New long-range photoelectric control system for protecting large areas against intrusion uses invisible modulated infrared radiation and the new Firetron lead sulfide receiver.—*Electronics Corp. of America, 77 Broadway, Cambridge, Mass.*

For more information circle **368** on inquiry card.

PHOTOELECTRIC HEADS

New small phototube and light-source heads are housed in 1⅞x1¾x 3⅝" gasket-sealed cast-aluminum



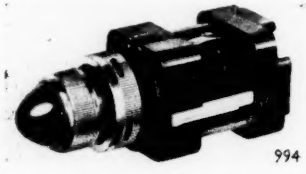
cases; screw on to ½" pipe or conduit for both support and wiring which simplifies rigid mounting; heads are also available with 6-ft flexible armored cables.—*Autotron, Inc., P. O. Box 722-Q, Danville, Ill.*

For more information circle **369** on inquiry card.

pilot lights, etc.

PUSH-TO-TEST PILOT LIGHT

New design incorporates features of Class 9001 Type T pilot light line,

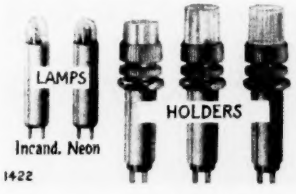


with a separate circuit to test bulb simply by pushing on color cap.—*Square D Co., 4041 N. Richards St., Milwaukee 12, Wis.*

For more information circle **370** on inquiry card.

INDICATING LAMPS

New miniature indicators utilize T-2 lamp, provide maximum data



readout capacity and medium or extra side visibility.—*Eldema Corp., 1805 Belcroft Ave., El Monte, Calif.*

For more information circle **372** on inquiry card.

SUBMINIATURE INDICATOR LAMP ASSEMBLIES

New Litestrip forms a complete decade ready for assembly into computers, annunciators, etc., at a cost less than that of installing individual lamps. Various digits, colors, direction of read-out and dimensions are available. Incandescent lamps for 1.3 to 28 vdc, or new NE2C subminiature neon lamp for higher voltages. Integral series resistors available in each lamp if desired. All lamps are replaceable.—*Circon Component Corp., Santa Barbara Municipal Airport, Goleta, Calif.*

For more information circle **371** on inquiry card.

MINIATURE INDICATOR LIGHT ASSEMBLIES

New Digicator lights provide computers and other instruments with easily-mounted displays of numerals, letters or symbols; are available individually, in pre-assembled strips, or as custom-built assemblies. Round or square lenses, accommodating AN3140-type incandescent or neon lamps, are available. Square lenses can be removed individually even when nested.—*Hetherington, Inc., Delmar Drive, Folcroft, Pa.*

For more information circle **373** on inquiry card.

PIN-POINT
BOTTLENECKS
TIME RECORDER + TOTALIZER
Boost production in your plant by pinpointing lost time of men and machines. TR + T provides accurate data on any machine, process, operation. Records on-off time. Gives impersonal time-study information, true cost accounting, anticipation of parts replacement. Continuous 4-month tape needs no ink. Used in nation's foremost industries. Brochure on request. $65
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657 BROADWAY, NEW YORK

For more information circle **98** on inquiry card.

DO YOU NEED THE ADVANTAGES OF A POTENTIOMETER TYPE TRANSDUCER?

Servonic "Model H" pressure transducers retain system simplicity and high electrical output, but they offer these operational extras . . .

RUGGED	Vibration resistant – plus or minus 20 g's. – 100 to 2000 cps.
STAINLESS STEEL	Corrosion resistant – two corrosive fluids. – gauge and differential models.
LONG LIFE	Lubricated bearings and potentiometer. Sealed against the action of dust and humidity.
UNIQUE CONFIGURATION	Designed for "Stacking." Designed for easy access to electrical and fluid connectors.
OPERATIONAL RANGES	Temperature – minus 65°F. to plus 400°F. Pressure – 1000 to 10,000 psig. – 1000 to 10,000 psid.

SERVONIC INSTRUMENTS, INC. | **COSTA MESA CALIF.**

For more information circle **99** on inquiry card.

EPLAB

PYRHELIOMETER
For the Measurement of SOLAR RADIATION

Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

THE EPPLEY LABORATORY, INC.

Scientific Instruments

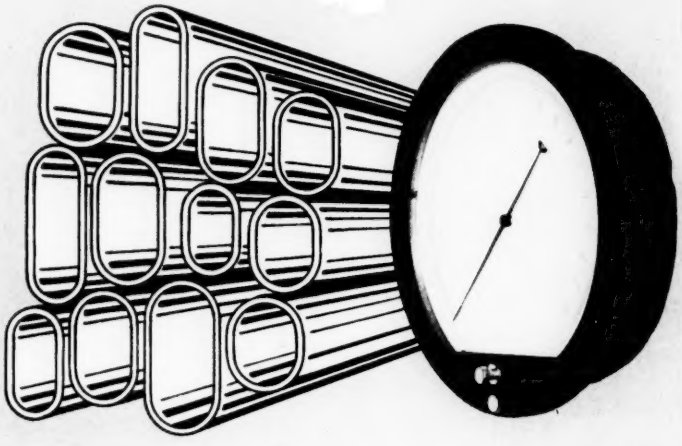
2 Sheffield Ave.
Newport, Rhode Island U. S. A.

For more information circle **100** on inquiry card.

HEISE GAUGES

Designed for Dependability

Does your high pressure gauge application require a scientifically designed Bourdon Tube?



Where highly accurate results are required design considerations such as the depth — width ratio of the Bourdon Tube section are of paramount importance.

Extreme fiber stress resulting from improper design of the tube may render an apparently good instrument completely undependable.

At the Heise Laboratories, mathematical solutions for determining the size and shape of Bourdon Tubes for specific use are augmented by years of research and tests on various types of tubes to assure correct stress distribution.

Heise Bourdon Tubes are heat treated by scientific methods to guarantee that each tube will be metallurgically sound for its application. The precision heat treatment of thin walled tubing without distortion has been made possible by equipment and technique developed by Heise Laboratories.

Catalog on Request

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"—12"—16"

Prices from $166.75 **DELIVERY WITHIN 30 DAYS.**

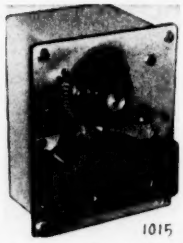
HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **101** on inquiry card.

time and sequence

SEQUENCE TIMER



New Model HDC features high switching capacity (10 amp 115 vdc, or 15 amp 115 vac) but its driving motor draws only 8 ma at 6 vdc. Motor's speed varies only ±1% for a voltage shift of ±50%.—*Brailsford & Co., Inc., 670 Milton Rd., Rye, N. Y.*

For more information circle **374** on inquiry card.

INSTANT RESET DELAY

New Type BR thermal time delay resets instantly when its energizing circuit is interrupted, either during timing cycle or after its completion. Nine standard delay intervals from 2 to 300 seconds (others special). Energizing voltage 28 vdc. Contacts rated 2 amp up to 230 vac and 1 amp up to 32 vdc. Withstands 30 G shock.—*G-V Controls Inc., 28 Hollywood Plaza, East Orange, N. J.*

For more information circle **375** on inquiry card.

TIME DELAY RELAYS

New models of Agastat time delay relays are available with an octal plug feature wired internally to allow immediate installation and operation. New front-facing terminal extensions for Agastat time delay permit quicker and easier installation in a panel; are available with Agastat units or separately.—*A'G'A Div., Elastic Stop Nut Corp., Elizabeth, N. J.*

For more information circle **376** on inquiry card.

ELECTRONIC TIMER

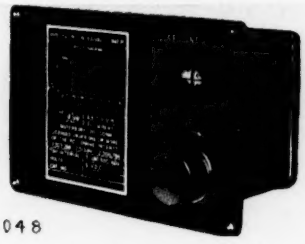
New CK Model 120, available in 8 ranges from 0.2 sec to 24 sec, is said to provide "all the features found in over 40 timers designed and developed for special applications." Among features: stop-motion control by external control switch that discharges timing capacitor; self-reset timing

with several units in sequence by hold-in of load relay; momentary-start with non-repeat self reset; repeat-cycle timing; dc starting relay to permit use of 115-v 25-400-cps current; two sets of sp-dt 8-amp contacts, one set to operate at start, one set at end of time delay.—*Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.*

For more information circle **377** on inquiry card.

INTERVAL TIMERS

New hermetically-sealed precision repeat cycle timers feature novel switching system which allows high

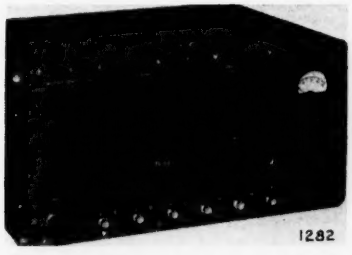


accuracy over long-range timing intervals; are available with chronometrically governed dc motors or synchronous ac motors.—*A. W. Haydon Co., Waterbury 32, Conn.*

For more information circle **378** on inquiry card.

PULSE TIMER

New Pulse Timer, for accurate measurement of delays in radar applications, differs from conventional



time delay generators in that it uses one pulse chain to produce both fixed and delayed pulse. Delays up to 10,000 usec can be measured with an accuracy of 0.01 usec.—*Teletronics Laboratory, Inc., 54 Kinkel St., Westbury, L. I., N. Y.*

For more information circle **379** on inquiry card.

COUNT-DOWN TIMER

New Count-Down Timer comprises a master unit and, if desired, from 1 to 10 slave units operated in per-

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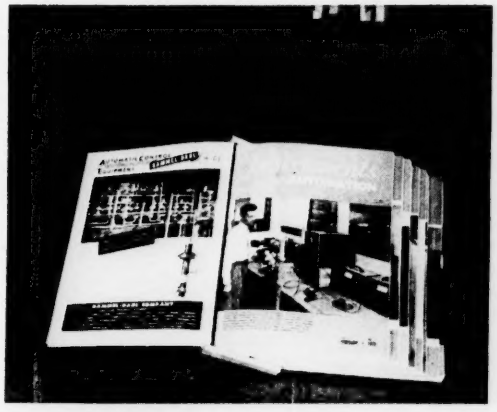

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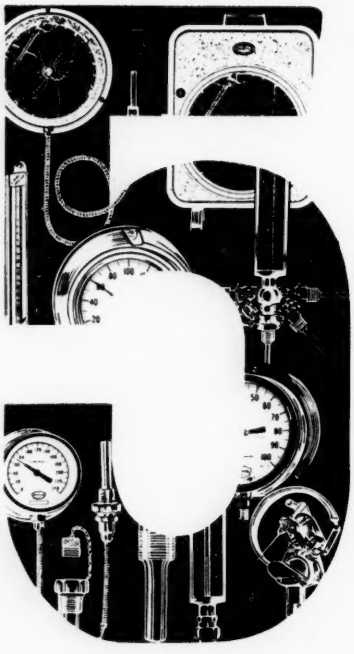

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FREEPORT, L. I., NEW YORK

For more information circle **103** on inquiry card.

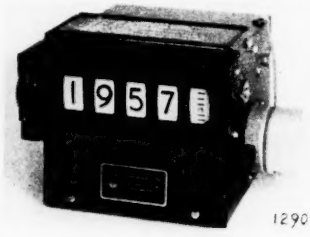
NEW INSTRUMENTS

fect synchronization. It can be preset at 199 minutes or fewer. It shows a — sign in front of all numbers and counts down and displays by the second. At 0 time, a 1-second circuit closure occurs, the — changes to a +, and unit proceeds to count to +30 minutes, by the second. It can be stopped, restarted, or reset at any or + or — time.—*Industrial Electronic Engineers, 3973 Lankershim Blvd., Hollywood, Calif.*

For more information circle **380** on inquiry card.

DIGITAL CLOCK

New Model T-2460 covers 24 hours; has digital outputs in mechanical con-



tacts down to minutes; can actuate a printer or other output device.—*Wang Laboratories, Inc., 37 Hurley St., Cambridge 41, Mass.*

For more information circle **381** on inquiry card.

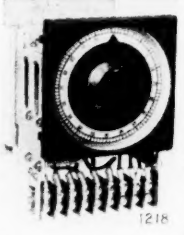
ELAPSED TIME INDICATORS

New Series 25200 subminiature hermetically-sealed elapsed time indicators meet MIL requirements, are available with 400-cps motors for 115-v operation. Illustration shows digital version reading to 0.1 hr; not illustrated is dial version.—*The A. W. Haydon Co., Waterbury, Conn.*

For more information circle **382** on inquiry card.

counting

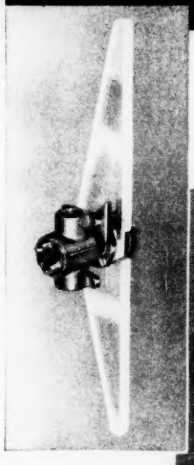
ADD-SUBTRACT COUNTER



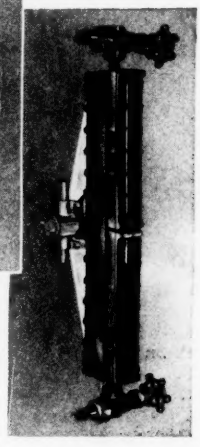
New add-subtract counter provides automatic control for conveyor systems, automatic storage hoppers, etc. Add and/or subtract pulses can be fed to it in any sequence or simultaneously without a miscount. When wired for continuous count and maximum switch set at 50 on dial, an output pulse will be secured every 50 pulses. *Eagle Signal Corp., Moline, Ill.*

For more information circle **383** on inquiry card.

PENBERTHY ILLUMINATORS
FOR LIQUID LEVEL GAGES



No Glare



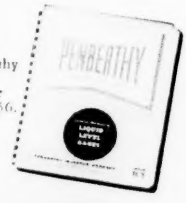
Clear Illumination of Liquid Level

Penberthy explosion-proof, dust-tight illuminators . . . with clear, plastic wedge . . . distribute bright EVEN light along entire length of gage glass. Rear lighting makes liquid level stand out sharp and clear. Accurate readings are easier from all angles and longer distances.

Explosion-proof illuminators can be installed on gages now in service, or on new gage installations. Available in single and double sections; for gages with three or more sections, order combinations of both . . . specify gage size or length of visible slot.

Standard 25 watt bulb and electric wiring housed in aluminum casing. Adjustable brackets permit easy installation to gage cover. Approved by U.L.I. for electric lighting fixtures used in hazardous locations for Class 1, Groups C and D service.

For information on the complete line of Penberthy gages, valves and accessories, WRITE for NEW Catalog #56.
Dept. A



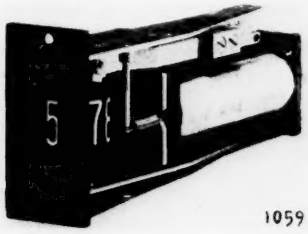
PENBERTHY

PENBERTHY MANUFACTURING CO.
Division of Buffalo-Eclipse Corporation
1242 Holden Ave., Detroit 2, Michigan

For more information circle **104** on inquiry card.

SINGLE-DECADE COUNTER

New Sodeco Type 1 TD counts normally or backward at speeds up to 25 impulses per second, enables re-



mote presetting for predetermining control. Units can be used independently as decades or interdependently. —*Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y.*

For more information circle **384** on inquiry card.

level

GLASSLESS L-L GAGE

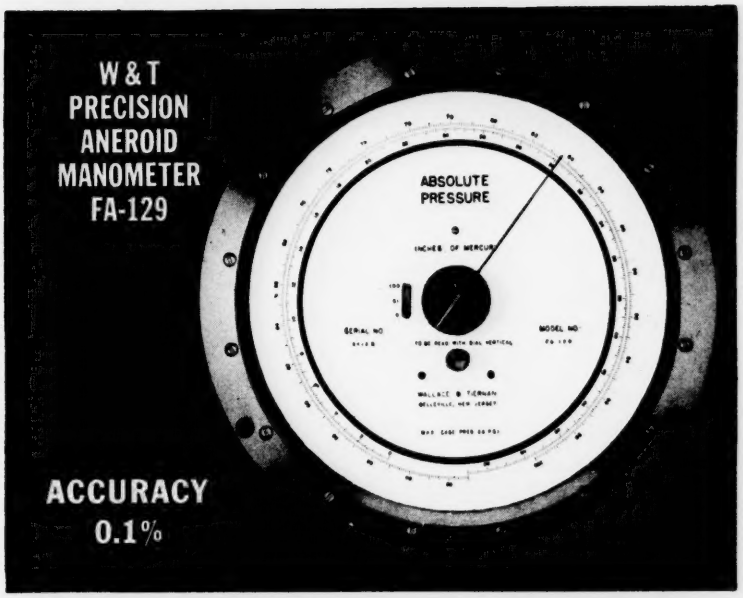
New steam-boiler water-level gage comprises a non-magnetic steel pipe enclosing a metal float (in man's hand) which carries powerful magnet. As float rides up and down on water in tube, magnet causes white-painted metal reeds (left) to become visible one-at-a-time through window on front of gage (removed from picture).—*Charles Englehard, Inc., 850 Passaic Ave., East Newark, N. J.*

For more information circle **385** on inquiry card.

MAGNETIC L-L GAGE

New Magnetic Gage, for observation of liquid levels or interfaces where conventional gages cannot be tolerated owing to dangerous inflammable or explosive conditions, features magnetic actuation of scale through wall of stainless-steel chamber containing gaging mechanism. Scale is a series of edge-magnetized wafers attracted to one another to give a continuous scale. One side of wafers is bright red, the other side silver. Changes in level raise or lower float which in turn magnetically turns over the wafers to display a continuous red band below level or interface and silver above. New gages are for pressures to 2500 lb @ 600°F. —*Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.*

For more information circle **386** on inquiry card.



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Ranges: 0 to 31.5 inches of Hg. absolute (min.)
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Other intermediate ranges available

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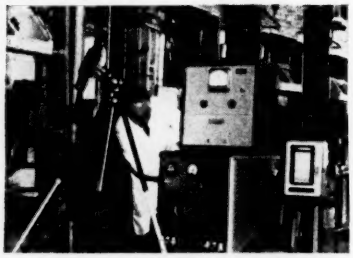
For more information circle **105** on inquiry card.

Critical Problem in Titanium Forging is Solved—



with INFRARED

Republic Aircraft hit problems — heat problems — in forming titanium sections. The metal had to be held within a *close* temperature range even during the actual working under the hammer.

Resistance heating was the natural way for bringing the blanks up to temperature . . . but the stopper was how to maintain adequate control of temperature while handling the metal in the press. Then Republic turned to Servo Corporation's infrared pyrometers, and found they had the answer.

Remote control of the temperature, *without* any connection or contact with the metal or machine, is maintained in this application by the SERVOTHERM Infrared Pyrometer. The SERVOTHERM provides highly accurate and instantaneous control of the temperature, the process, *or both*, in almost any kind of operation, by measuring the infrared radiation emitted by the material or equipment involved.

Almost any control problem, where heat is a related variable — whether of a basic *or* an incidental nature — is easily solved with a SERVOTHERM Pyrometer System. The effectiveness of infrared control applies to materials or objects that are moving or stationary, whether liquid, solid, or powdered — granular in form, in the temperature range from 40° to 2800°F.

The leading firm in infrared, Servo Corporation of America produces the world's widest range of infrared equipment — systems and components, assemblies and accessories. The modular principle of building custom IR systems from "standard units" is also a Servo Corporation development.

For data on Servo Corporation's infrared equipment, from single items to complete IR systems for almost any type of control function — in laboratory or production line use, write for our new technical bulletin on Infrared Pyrometers, TDS IRPS-R1, or consult our application engineering staff. Call or write:

SERVO CORPORATION of AMERICA

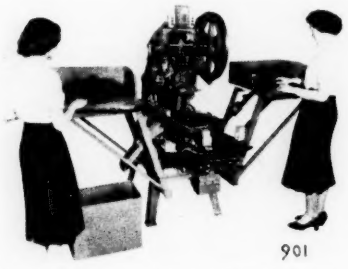
20-12 Jericho Turnpike, New Hyde Park, L.I., N.Y.

For more information circle **106** on inquiry card.

shop equipment

COLOR STAMPING PRESS

New Multi-color Hot Stamping Press is standard 2AH press with a special front extension to which a

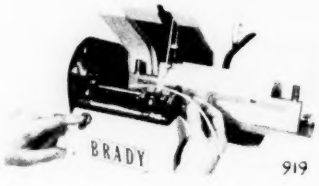


large-dial automatic feed and electronic controls have been incorporated. Two or three colors can be hot-stamped at one time.—*The Acromark Co., 543 Morrell St., Elizabeth 4, N. J.*

For more information circle **387** on inquiry card.

AUTOMATIC WIRE MARKING

New Markermatic automatic wire marking machine enables one operator, using self-sticking Perma-Code



wire markers, to mark as many as 1000 wires per hour.—*W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis.*

For more information circle **388** on inquiry card.

TUBING TOOL KIT

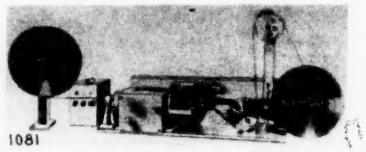
New kit contains tubing tools most needed for instrumentation service: for cutting, flaring, bending, swaging

and temperary closure of tubing.—*The Imperial Brass Mfg. Co., 6300 W. Howard St., Chicago 31, Ill.*

For more information circle **389** on inquiry card.

AUTOMATIC WINDER

New Model 209 continuous resistance winder is completely automatic: requires no operator except to start

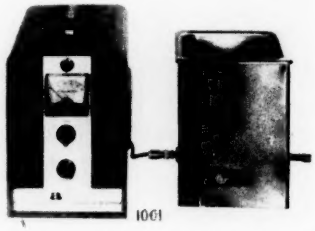


and stop. It winds resistance wire on continuous lengths of flat or round core material to be cut to desired length. Optional predetermining counter stops machine at any given footage length.—*Geo. Stevens Mfg. Co., Inc., Pulaski Rd. at Peterson, Chicago 30, Ill.*

For more information circle **390** on inquiry card.

ULTRASONIC CLEANER

New low-priced portable Model DR 50-AH comprises a compact generator and a transducerized stainless steel



corrosion-resistant ½-gal tank with rounded corners.—*Acoustica Associates, 26 Windsor Ave., Mineola, N. Y.*

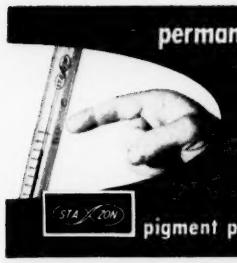
For more information circle **391** on inquiry card.

ULTRASONIC GENERATOR

New Model AP-206 Sonogen simplifies manual or conveyorized cleaning and degreasing; is suitable for many

types of production cleaning equipment, such as pictured Blakeslee trichlorethylene vapor degreaser.—*Branson Ultrasonic Corp., 40 Brown House Rd., Stamford, Conn.*

For more information circle **392** on inquiry card.



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PRINCO laboratory thermometers are your assurance of everlasting legibility, easier readability and greater accuracy—for their STAZON markings will withstand the action of acids, caustics, and solvents, or any liquid which will not harm glass.

Look for the name STAZON enclosed in the infinity mark. It is your guarantee that the graduations and figures, which have actually become part of the glass itself, will remain legible for the life of the thermometer.

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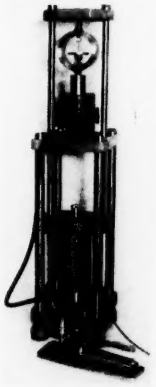
For more information circle **107** on inquiry card.

INACCURACY IS COSTLY!

check your

THRUST STANDS
TESTING MACHINES
DYNAMOMETERS
WEIGHING SYSTEMS

with MOREHOUSE PROVING RINGS



Inaccurate force measurement systems waste time and money. For maximum accuracy, be sure to calibrate your systems regularly with a MOREHOUSE PROVING RING . . . the industry standard for over 30 years. Every MOREHOUSE PROVING RING is calibrated and certified by the National Bureau of Standards.

The MOREHOUSE UNIVERSAL CALIBRATING MACHINE (left) facilitates the calibration of compression and tension type load cells in capacities ranging from 10,000 lb. to 100,000 lb.

Learn the construction, operation and application of proving rings . . . write today for the 16 page book, "THE A B C's of ACCURACY."

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For more information circle **108** on inquiry card.

INSTRUMENT ENGINEERS . . .

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- GAS ANALYZERS
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- AIR GAUGING EQUIPMENT
- GAS CHROMATOGRAPHY
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- GAS TRANSMISSION CONTROL PANELS
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quick shut-off

450 SERIES
TOGGLE VALVES

Feature quick, flip-of-the-handle action for positive vacuum-tight shut-off. Helium leak tested. Molded nylon handles come in colors for coding instrument operations. Available in brass or 303 SS for 200 psi service in 1/8", 1/4" and 3/8" sizes.

or

reverse flow check

570 SERIES
CHECK VALVES

Feature extremely effective leak-tight seal, exceptional flow characteristics and low-cost. Synthetic rubber seats and stainless steel springs give maximum corrosion resistance. Available in brass or 303 SS in ball and piston types for 5000 psi service in sizes 1/8" through 1/2"

Why buy big when you can buy small

OK

HOKE INCORPORATED
Fluid Control Specialists
231 South Dean Street
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For more information circle **67** on inquiry card.

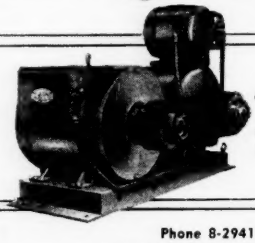
KATO VARIABLE FREQUENCY
MOTOR GENERATOR SETS
For Better Bench Mock-Up Tests!

VARIABLE FREQUENCY MOTOR GENERATOR SETS
adjust 360 to 440 CPS. Generator mounted controls include reset buttons, limit switch. Motor and generator remain stationary. Variable drive pulley adjustment is controlled by small motor.

CONTROL PANELS
Synchronous motor starter and generator controls including magnetic amplifier voltage regulator in cabinet.

REMOTE CONTROL
Remote control frequency adjustment varies speed from 1080 to 1320 rpm., thus varying frequency. Bench Mock-Up Test Station may be located anywhere.

MANUAL ADJUSTED MODELS
Continuously adjustable, holds speed accurately. Simple hand wheel controls variable-pitch V-belt arrangement permitting the often desired frequencies of 36, 40, 50, 60 and 70 cycles per second. Output indicated by frequency meter. Single, 3 phase or D. C. drive motors available. Also other frequency ranges.



Also 60 CYCLE A.C. GENERATORS from 350 watts to 500 KVA.

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Hold it with an H. J. J. Screw-holding Driver

Sizes to handle from #0 to #¼" screws

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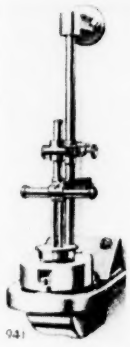
268 Marlow Drive • Oakland 5, California

For more information circle **111** on inquiry card.

dimensional gaging

SELF-CHECKING COMPARATOR

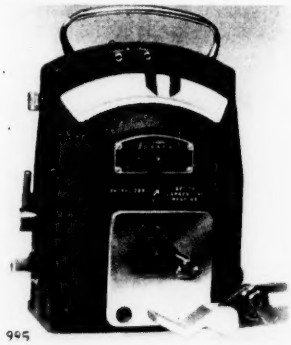


New high-precision comparator, NPL design, is for exact measurement of gage blocks and length bars. Wall mounting type will check a gage up to 40"; bench type to 14". As end bars are positioned vertically for checking, problem of sag does not have to be considered. Readings can be made to 0.000001".—*Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.*

For more information circle **393** on inquiry card.

PRECISION I. D. GAGE

New PG-800 is said to represent "a completely new method of precision-measuring internal diameters." Size

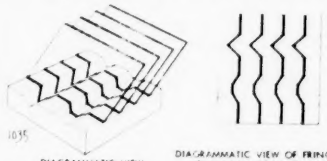


range ⅜" to 1½" ID; linear scale 0.005"; magnification 1000:1.—*Sunnen Service Corp., 7900 Manchester Ave., St. Louis 17, Mo.*

For more information circle **394** on inquiry card.

MICROINCH SURFACE FINISH MICROSCOPE

New Hilger & Watts Surface Finish Microscope, by using interference fringes, permits checking surface fin-



DIAGRAMMATIC VIEW OF A GROOVED SURFACE INTERCEPTED BY IMAGINARY PLANES

DIAGRAMMATIC VIEW OF FRINGES SHOWN IN ACCOMPANYING ILLUSTRATION AS SEEN IN THE SURFACE FINISH MICROSCOPE

ish in terms of light wavelengths, yet can be used easily in shop as well as in Standards room or lab. It measures roughness of flat or curved surfaces directly to an accuracy of 1 microinch without calculations or use of tables. An easily adjusted camera attachment records on 35-mm film.—*Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.*

For more information circle **395** on inquiry card.

GRINDER GAGE

New Sure-Set work-positioning gage positions swivel table on universal grinders so that operator can produce work of desired straightness, cylindrical or tapered, without need for charts, tables, mathematics, or trial-and-error grinding. Its two electronic gage heads locate at ends of grinder table and computing circuitry associated with amplifier corrects for difference between work length and table length.—*Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

For more information circle **396** on inquiry card.

ULTRASONIC GAGING TRANSDUCER

New Type Z will detect even flaws close to surface of material under test. Immersion-mounted units are

waterproof and can operate continuously at 250° F; contact-testing units will withstand 450°F. Available for frequencies of 0.5 to 10 Mc; can be coupled to testers of all makes.—*Branson Instruments, Inc., 40 Brown House Rd., Stamford, Conn.*

For more information circle **397** on inquiry card.

mechanical testing

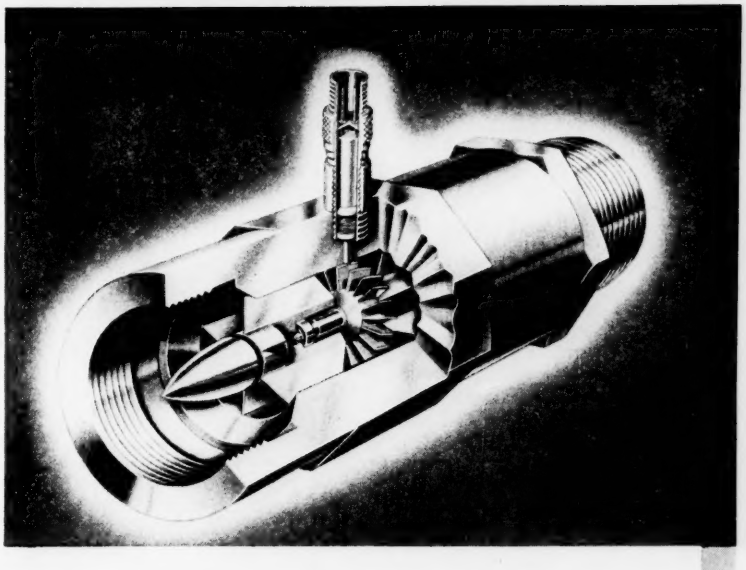
TENSION METER

New Saxl Tension Meter for measurement of tension during wire processing features low deflection, negligible wire contraction, quick automatic trigger action, new aluminum body and new black plastic sides for sure grip even in high humidity.—*Tensitron, Inc., Harvard, Mass.*

For more information circle **398** on inquiry card.

HARDNESS TESTER

New improved portable metal hardness tester provides direct readings from Rockwell "A," "B" or "C" scales or Brinell Medium or Low Scales, on practically any size, shape or type of metal. Each instrument is individually calibrated; comes complete with diamond penetrator and



★ Meticulously calibrated to insure 1/2% accuracy
★ Easily disassembled for cleaning
★ High frequency output — 120 to 1200 cps
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★ Unharmed by reverse flow

new cox turbine flowmeter

For over 46 years the name "Cox Instruments" has been synonymous with *precision* flow measurement. Such outstanding equipment as Cox Variable-Area Flowmeters and Cox Calibrating Stands have helped make it possible for industry to establish realistic standards for accuracy and reliability in flow measurement.

And now . . . the Cox *Turbine* Flowmeter joins this list of truly precision products. Developed to meet the exacting needs of modern instrumentation systems, it has received the acclaim of initial users throughout industry.

We welcome the opportunity to tell you more about the complete line of Cox Turbine Flowmeters. Write to *Cox Instruments Division, George L. Nankervis Company, 15200 Fullerton Avenue, Detroit 27, Michigan.*

COX INSTRUMENTS

A new technical bulletin describes the complete line of cox turbine flowmeters. Ask for bulletin no. 1300a.

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For more information circle **112** on inquiry card.

NOW! KAHN offers the NEW!

KAHN HEATLESS DESICCANT AIR DRYERS

Reactivated without heat

Check these advantages:

* Costs reduced on installation and maintenance.
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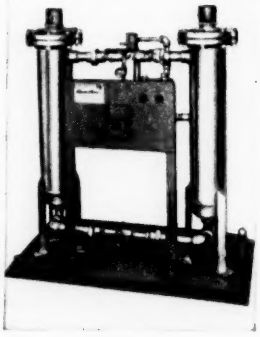

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KAHN DRYERS
all the way . . .

Kahn has a complete line of electric or steam regeneration dryers - automatic, semi-automatic or manual operative. Operating pressures up to 5,000 psi.

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For more information circle **113** on inquiry card.

Flow Visualization Instrumentation

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For more information circle **114** on inquiry card.

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WHAT'S YOUR ENGRAVING PROBLEM
There's a Model to solve all your problems. Preis is the "one source" solution for your engraving problems. Complete line of accessories and attachments are available for all makes and models.

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TRADE MARK PANTO

Write for complete details and prices. For immediate attention write directly to manufacturer below. Ask for nearest representative.

H. P. PREIS Engraving Machine Co.
661 U. S. Highway 22 Hillside, N. J.

For more information circle **115** on inquiry card.

NEW INSTRUMENTS

one test block packed in wood case. For continuous-run testing, a bench adapter is also available.—*Newage Industries, Inc., 222 York Road, Jenkintown, Pa.*

For more information circle **399** on inquiry card.

TESTING MACHINE

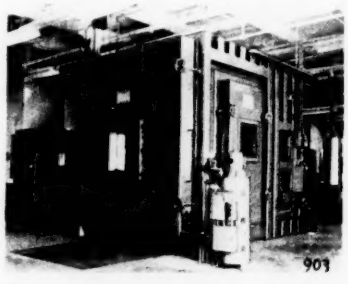
New 10,000-lb Mark G Servomatic is the first testing machine with (1) force-measuring system incorporated

in cross-head, measuring forces between cross-head and actuating nut assembly rather than forces transmitted to base of machine; and (2) center of test fixed at 56½" above floor.—*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Waltham, Mass.*

For more information circle **400** on inquiry card.

ENVIRONMENT TEST CHAMBER

New Temperature-Altitude-Humidity walk-in, for simulated flight testing of electronic components, features

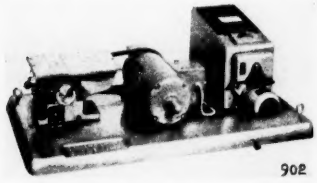


vibrator on tracks which allows in-the-chamber specimen vibration simultaneously with environment testing over ambient range of −100°F to 300°F; relative humidity 20% to 100% and altitude from sea level to 100,000 ft or more.—*American Research Corp., Farmington, Conn.*

For more information circle **401** on inquiry card.

FATIGUE TEST MACHINES

New series of three vibration fatigue testing machines provide frequencies from 5 to 100 cps compared



to 10 to 60 cps of present models. Cycling can be controlled manually or automatically (from 5 to 100 cps and back to 5 repeatedly, or any segment such as 5 to 11 or 70 to 90); or can be held at one frequency.—*All American Tool & Mfg. Co.*, 8011 *Lawndale Ave., Skokie, Ill.*

For more information circle **402** on inquiry card.

PENETRATION TESTER

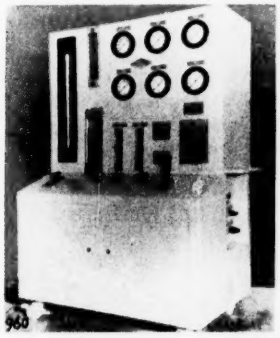
New Ball Penetration Apparatus determines consistency of fresh con-

crete; conforms to ASTM spec C-360 considered to be faster and simpler than conventional slump test.—*Soiltest, Inc.*, 4711 *W. North Ave., Chicago 39, Ill.*

For more information circle **403** on inquiry card.

PNEUMATIC TEST STANDS

New automatized test stands have reportedly reduced aircraft pneumatic checkout time by as much as 80%.

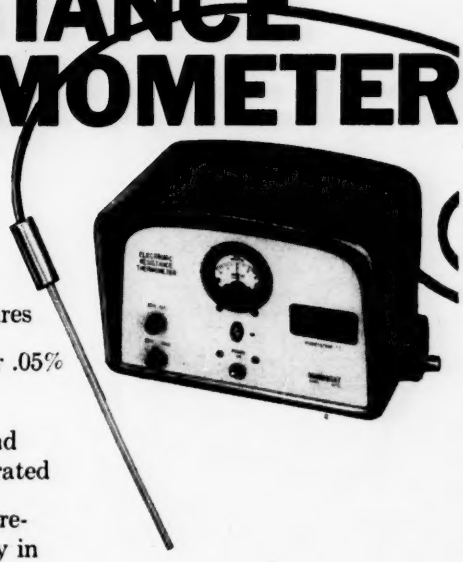


Model shown provides regulated air pressures at various levels from 0 to 500 psi.—*Kinetrol Co.*, 5543 *Dyer St., Dallas 6, Texas.*

For more information circle **404** on inquiry card.

now! the only thermometer for direct reading temperatures from -100°c to 900°c with .01°c sensitivity!

ELECTRONIC RESISTANCE THERMOMETER



- digital read-out for direct reading temperatures
- high accuracy—0.1°c or .05% whichever is greater
- each resistance bulb and bridge individually calibrated
- bulbs are aged so that recalibration is unnecessary in changing temperatures
- vacuum sealed platinum elements and leads in resistance bulb: hermetically sealed head, choice of stainless steel or quartz jacket
- plug-in controller accessory with .05°c reproducibility

For more information, including operating characteristics, a technical data sheet is available upon request.

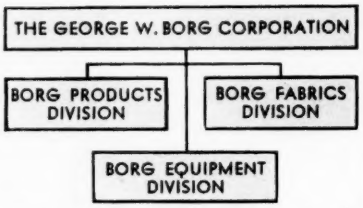
HOKE-MANOSTAT CORP.

148 s. dean st., englewood, n. j.

For more information circle **116** on inquiry card.

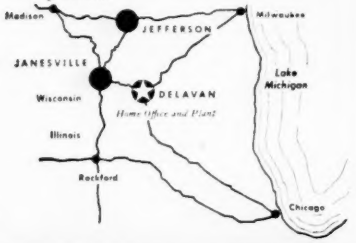
WHO IS BORG?

George W. Borg, who founded this corporation, is the "Mr. Clutch" who started with Borg & Beck. He then helped organize the Borg-Warner Corporation of which he became president. Later he served as chairman of the board until he resigned to devote his full attention to The George W. Borg Corporation.



The George W. Borg Corporation is comprised of three divisions

- **Borg Products Division**
  Manufactures automotive clocks.
- **Borg Fabrics Division**
  Manufactures deep-pile fabrics best known of this line is the fashionable "Borgana" fabric.
- **Borg Equipment Division**
  Manufactures Micropots (precision potentiometers), Microdials (precision turn-counting dials), instrument motors, frequency standards, aircraft navigational instruments and components for systems.



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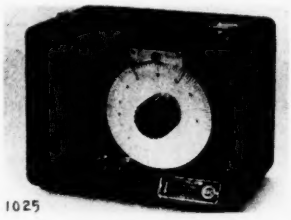
For more information circle **117** on inquiry card.

electrical testing

TEST OSCILLATOR

New Model 20A, featuring all-transistor circuitry, printed wiring, and battery operation, is continuously

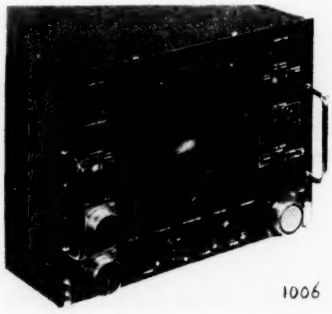


variable from 15 cps to 150 kc at a source impedance under 0.5 ohm.—*Consol. Electrodynamics Corp., 325 N. Altadena Drive, Pasadena, Calif.*

For more information circle **405** on inquiry card.

TEST MONITOR

New C-Series Monitorscope makes it possible to inspect at a glance up to 86 test-point variables. Individual

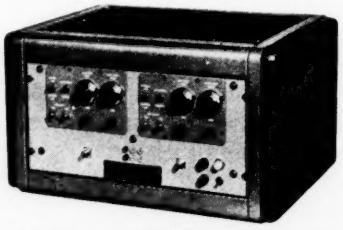


data samples are presented in bar-graph form with amplitude component of specific markers equivalent to information content at data source.—*Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.*

For more information circle **406** on inquiry card.

DUAL CHANNEL ANALYZER

New Model 405 Dual Channel Pulse Height Analyzer provides 200,000 counts per second in range of 3 to



140 volts, provides for both integral and differential spectrum analysis; also enables studies of energy distribution of nuclear particles when used with a linear amplifier or scaler.—*Franklin Electronics, Inc., Dept. 426, Bridgeport, Pa.*

For more information circle **407** on inquiry card.

Telemeter ANY VARIABLE from Remote Points

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

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Radio Frequency
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Boonton, New Jersey, U. S. A.

For more information circle **118** on inquiry card.

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FROM THIS

TO THIS

OR THIS

WITH THE REVOLUTIONARY PRODUCTION AID TOOL!

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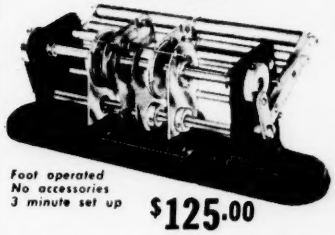

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PIG-TAILORING eliminates: • Diagonal cutters • Long nose pliers • Operator judgment • 90% operator training time • Broken components • Broken leads • Short circuits from clippings • 65% chassis handling • Excessive lead tautness • Haphazard assembly methods.

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Close-up views of "SPIN-PIN" illustrate fast assembly of tailored-lead wire to terminal.

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- No Pliers
- No Clippings
- Uniform Crimps
- 22 Sizes

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DESIGNERS & MANUFACTURERS OF ELECTRONIC EQUIPMENT

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For more information circle **119** on inquiry card.

POWER OSCILLATORS

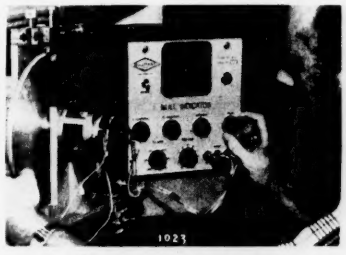
New fixed-frequency power oscillators provide 6 watts of extremely stable, harmonic-free ac power. Single

or multiple channel units range in frequency from 200 to 15,000 cps and from 10 to 150 volts rms output into a 6-watt load.—*Cardinal Instrumentation Corp.*, 4201 *Redwood Ave., Los Angeles 66, Calif.*

For more information circle **408** on inquiry card.

NON-LINEAR POT TESTER

New test system for non-linear carbon-film precision potentiometer resistors assures that a typical test plot



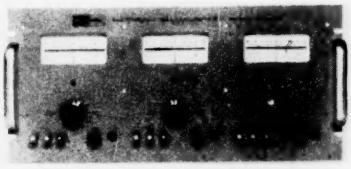
of error every 3° of pot angle to a system accuracy of one part in 50,000 can be made "in 1/10 of the time usually required."—*Computer Instruments Corp.*, 92 *Madison Ave., Hempstead, N. Y.*

For more information circle **409** on inquiry card.

electrical and electronic instruments

3-UNIT GALVANOMETER

New Model 204AR-3 comprises three Model 204A Electronic Galvanometers which are combination dc



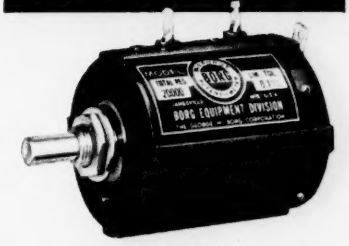
null detectors, linear deflection indicators, microvoltmeters, micromicroammeters, and low-level dc amplifiers. Their 2×10^{-11} amp-per-division sensitivity is twenty times better than that of high-quality mechanical current galvanometers.—*Kin Tel*, 5725 *Kearny Villa Rd., San Diego, Calif.*

For more information circle **410** on inquiry card.

RMS VOLTMETER

New Model TBM Random Signal True Root-Mean-Square Voltmeter is said to be the first true rms volt-

BORG 205 SERIES MICROPOTS...



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Borg 205 Series MICROPOTS have proven themselves exceptionally rugged and dependable. They have given years of service in many different mobile and stationary applications for both military and commercial uses. They're readily available, too, as Borg's modern production facilities assure prompt delivery in any quantity. Write today for the name of your nearest Borg Jobber or "Tech-Rep". It will pay you to know him.

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- ✓ Accurate setting and resetting due to anti-backlash spring in contact guide!
- ✓ Permanent accuracy because resistance wire is moulded integrally with housing!
- ✓ Long life because slider-contact is the only moving member that touches the resistance element.

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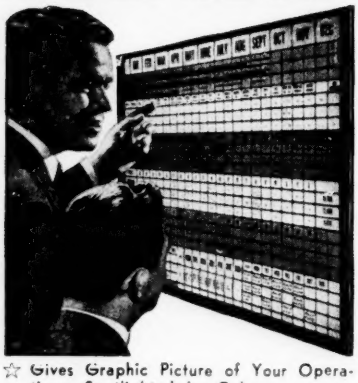

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Two standard models: B20—½" dia. x 20" long and B29—½" dia. x 29" long. Write today for Technical Bulletin #8500.

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10122 E. Rush St., El Monte, California

For more information circle **122** on inquiry card.

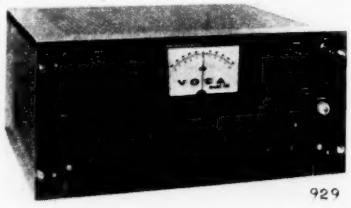
NEW INSTRUMENTS

meter to provide "accurate, steady long-time-average measurements in the presence of low-frequency signal components." Features include panel switch selection of FAST (about 0.1 sec) for quick estimates of rms level and SLOW (about 10 sec) for exact rms measurements through a thermal squaring-averaging device. Bandwidth 2 cps to 250,000 cps flat ±0.2 db. Eighteen voltage ranges from 500 microvolts to 250 volts rms full-scale. Peak factor 10. Calibration and overload protection are built-in. Aluminum cabinet 8" W, 7" H, 12" D.—*Flow Corporation, 88 Mystic St., Arlington 14, Mass.*

For more information circle **411** on inquiry card.

AC VOLTMETER AND VTVM

New VOCA is a new type of multifunctional instrument combining (1) the first differential null type potentiometer voltmeter and calibrator for both ac and dc, (2) a VTVM. With it, the potentiometric differential null type of measurements can be applied to rms sine wave voltages; and built-in highly accurate and stable reference standards are available for calibrator functions.—*Demolab Corp., Instrument Div., 1500 N. Highland Ave., Hollywood, Calif.*



929

For more information circle **412** on inquiry card.

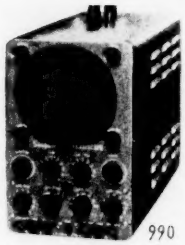
PORTABLE POTENTIOMETER

New Thermotest-I featuring interchangeable scales and automatic compensation is said to permit measurements of a wider range of temperatures and voltages than possible before with any one instrument. Three aluminum scales for thermocouple temperatures and one for 0-21 millivolts.—*Technique Associates Inc., P.O. Box 91, Indianapolis 6, Ind.*

998

For more information circle **413** on inquiry card.

GENERAL-PURPOSE 'SCOPE

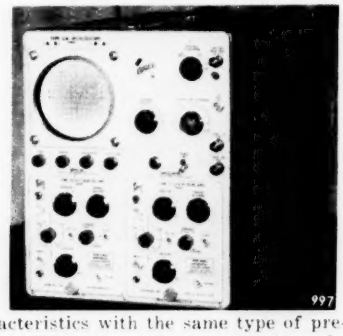

990

New Handiscope Model 466 has 5" screen, filter-type graticule, and universal-fit bezel; also incorporates construction features designed to increase ruggedness and give dependable operation under hard usage.—*Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.*

For more information circle **414** on inquiry card.

OSCILLOSCOPE

New Type 536 High-Frequency X-Y Oscilloscope has identical horizontal and vertical deflection characteristics with the same type of preamplifier plugged into both channels. It converts to a general-purpose instrument when Type 53/54T Time-Base Generator (lower left) is plugged into horizontal amplifier.—*Tektronix, Inc., P. O. Box 831, Portland 7, Oregon.*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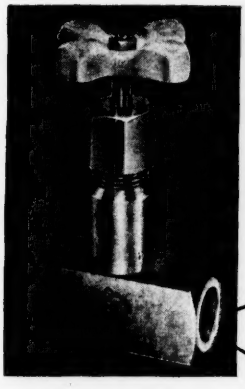
For more information circle **415** on inquiry card.

OSCILLOGRAPH

New 36-channel Model 1012 of Visicorder produces, as do previous models, records that are immediately visible and usable. In addition it incorporates a number of new features: grid lines can be recorded simultaneously with time lines and galvanometer traces; five speeds in each of three ranges by push button control; frequency response 3,000 cps without peaked amplifiers of any kind; writing speeds to 20,000 ips.—*Heiland Div. of Minneapolis-Honeywell Regulator Co., Denver, Colo.*

971

For more information circle **416** on inquiry card.



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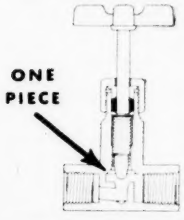
First needle valve to combine all the characteristics called for in modern industry. Embodies sturdiest basic construction—machined from solid bar stock—suitable for pressures to 10,000 psi and equally efficient in lower range. Note stem guide fused to body by new "Conoweld" process, eliminating faults of conventional two-piece valves. Stem 416 stainless steel. Stem threads fine pitch for strength and micrometer regulation. Body electro-zinc plated. Sizes ⅛" to 1", globe and angle patterns.



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Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd Street, Edmonton, Alberta, Canada

For more information circle **123** on inquiry card.

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As a result of research conducted by the P. M. T. Committee, a method of Permanently Marking Thermometers has been developed.

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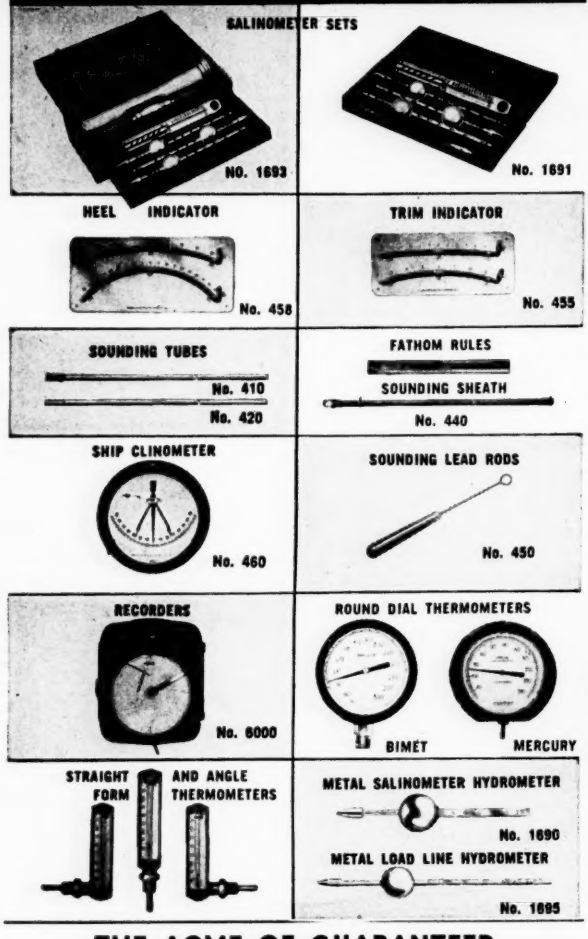
MOELLER MARINE INSTRUMENTS



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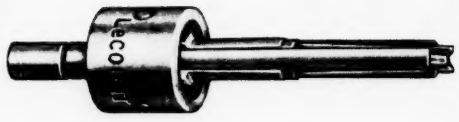

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Micro-Mite* expanding mandrels are miniature duplicates of the Count-Centric* straight jaw mandrels designed to enable precision instruments and electronic manufacturers to achieve miniaturization without the cost of special holding devices. Only 8 standard tools provide every arbor from ¼" to ½". Type "M" have a guaranteed concentricity of .0005" T.I.R. and Type "SM" have a guaranteed concentricity of .0002" T.I.R. LeCount welcomes the opportunity to design and produce a wide range of special mandrels for unusual bores.

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CHART FOLDING MACHINE

New Rollafold produces neat accordion folds in a paper strip or roll such as an oscillograph chart. Fold spacing is adjustable from 6.5" to 12.5".—*Benson Lehner Corp.*, 11930 *Olympic Blvd., Los Angeles* 64, *Calif.*

For more information circle **417** on inquiry card.

DECADE VOLTAGE DIVIDERS

New line of Kelvin-Varley Decade Voltage Dividers (supplementing older Series 830 and 840 with conventional potentiometer circuit) comprises four-dial Types 8348, 8349 and 8350 with input resistance from 10,000 to 100,000 ohms. All resistors are calibrated to 0.05%.—*Shallcross Mfg. Co., Collingdale, Pa.*

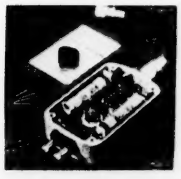
For more information circle **418** on inquiry card.

OSCILLOGRAPH CHARTS

New pre-printed orthochromatic photo-recording oscillograph paper charts, custom-made for each application and instrument, will enable oscillograph users to read test values directly from processed paper record; any width up to 12", slit, packaged, and rolled, with or without cores. Amplitude lines are printed to an accuracy of 0.005". Ultraviolet- and tungsten-sensitive photo-recording papers, in any of several speeds.—*The Bristol Co., Special Chart Div., Waterbury* 20, *Conn.*

For more information circle **419** on inquiry card.

DECADE AMPLIFIER



New Model 194G high-gain broad-band transistor ac decade amplifier for use with strain gages, etc., extends sensitivity of high-impedance-input 'scopes, VTVM's or null-balance recorders; operates from two 5-v mercury batteries.—*Taber Instrument Corp., N. Tonawanda, N. Y.*

For more information circle **420** on inquiry card.

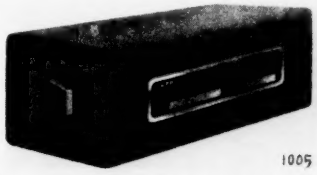
KVM MULTIPLIER

New inexpensive voltmeter multiplier for dc voltages up to 30 kv comprises an oil-immersed stabilized resistor sealed in a standard LA can; features voltmeter terminals protected with an internally connected glow discharge tube; is designed for 100-ua movements. Other units from 5 to 150 kv dc can be supplied.—*Del Electronics Corp.*, 521 *Homestead Ave., Mt. Vernon, N. Y.*

For more information circle **421** on inquiry card.

LF MECHANICAL OSCILLATOR

New Model X-0006, of sampling-switch type, produces a 150-cps square pulse whose width is variable from



10% to 80% of total channel width while oscillator is running.—*Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.*

For more information circle **422** on inquiry card.

NULL DETECTOR

New battery-operated Model 2050 All-Transistor Null Detector, when used with other battery-operated equipment, allows complete isolation from power lines, whence low noise level. Sensitivity with 400- or 1000-cps filter: in linear position 200 uv for full-scale and 80 uv for 30% deflection; in null position 2000 uv for f-s and 100 uv for 30% deflection. Frequency range 40 cps to 20 kv ± 1 db.—*Freed Transformer Co., Inc.*, 1721 *Weirfield St., Brooklyn* 27, *N. Y.*

For more information circle **423** on inquiry card.

LOGARITHMIC TRANSLATOR

New Model 6700 Logarithmic Translator features stability, wide frequency range and flat response. Output voltage varies in average value proportionately to log of input amplitude; can be fed directly to any averaging type indicator or oscillograph; can easily be resolved into a corresponding dc value with the aid of a simple *RC* network. Voltage range 1 mv to 100 v; frequency response 25 to 40,000 cps ±1 db.—*EV Instruments, Buchanan, Mich.*

For more information circle **424** on inquiry card.

FIVE ACCESSORIES FOR STRIP-CHART RECORDERS

New 3-Position Pen writes on chart margin and, with proper contacts on integrator output, makes every tenth

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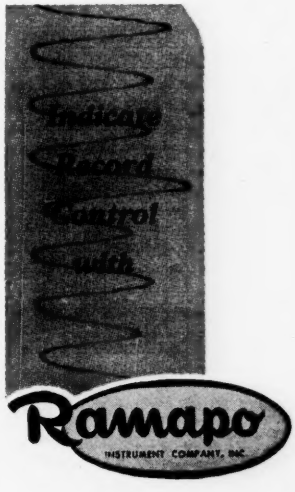
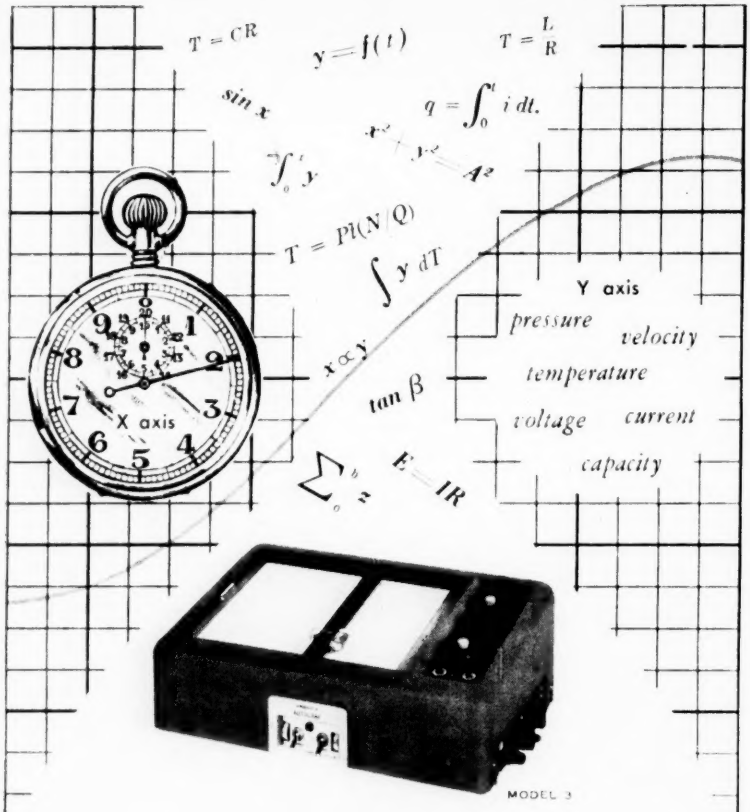


Bloomingdale, N. J.

For more information circle **127** on inquiry card.



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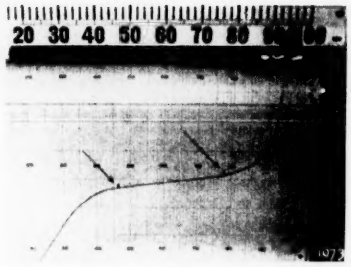


pip a different length. ★New Pen Jogger, useful in testing-machine work to identify knee, causes pen to make a vertical pip. ★New events Marker Pen (2- or 3-position) requires glass window to be replaced by a piece of plexiglas with a hole large enough for entrance of pen. ★New Curve Follower Pen is useful in producing a proven record on Brown-Royson Curve Follower. ★New Access Door permits keeping door locked while writing notes on chart.—*Royson Engineering, Hatboro, Pa.*

For more information circle **425** on inquiry card.

MAGAZINE PROCESSOR FOR OSCILLOGRAPH

New 5-036 Datarite direct-writing magazine attaches to standard Type 5-119 oscillograph; provides devel-

925

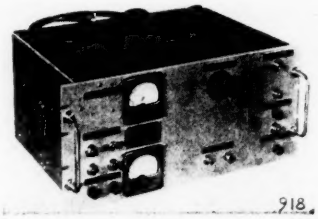
oped and dried photographic records as fast as instrument records data. —*Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.*

For more information circle **426** on inquiry card.

power supplies

HV DC POWER SUPPLIES

New Series 1000 rack-mounting high-voltage dc power supplies are available in 16 basic models with out-



918

puts from 0-1 to 0-50 kv at 2 to 500 ma, feature moderate prices and minimum operational hazards.—*Beta Electric Div., Sorenson & Co., Inc., 333 E. 103 St., New York 29, N. Y.*

For more information circle **427** on inquiry card.

TRANSISTORIZED SUPPLY

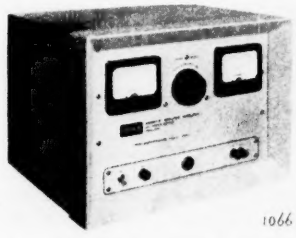
965

New PV-2 Inverter, completely transistorized, is designed to operate 50- or 60-cps synchronous motors from a 12-vdc source. It is tuning-fork controlled and can operate motors rated up to 140 va input.—*Mandrel Industrial Instruments, 5134 Glenmont Drive, Houston, Texas.*

For more information circle **428** on inquiry card.

DC POWER SUPPLY

New tubeless Model M60V delivers 0-32 v at 25 amp; contains no moving parts. Regulation accuracy 1% at 28



1066

v; ripple 1% rms. Immediate delivery.—*Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.*

For more information circle **429** on inquiry card.

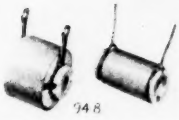
resistors

MICROMINIATURE VDR's

New Acesets (R) are microminiature ($\frac{1}{2}$" dia by $\frac{5}{8}$ L) precision wirewound voltage-dividing resistors said to "offer greater stability under temperature cycling than other types of comparable size;" will dissipate 2 watts at 60°C.—*Ace Electronics Associates, Inc., 99 Dover St., Somerville, Mass.*

For more information circle **430** on inquiry card.

CERAMIC WIREWOUND RESISTORS



948

New full line of commercial inexpensive stabilized GenRes Lug and Radial Lead Resistors comprises units reverse pi-wound to minimize inductance; available to order in values from 0.1 ohm to 10 megohms.—*General Resistance, Inc., 577 E. 156th St., New York 55, N. Y.*

For more information circle **431** on inquiry card.

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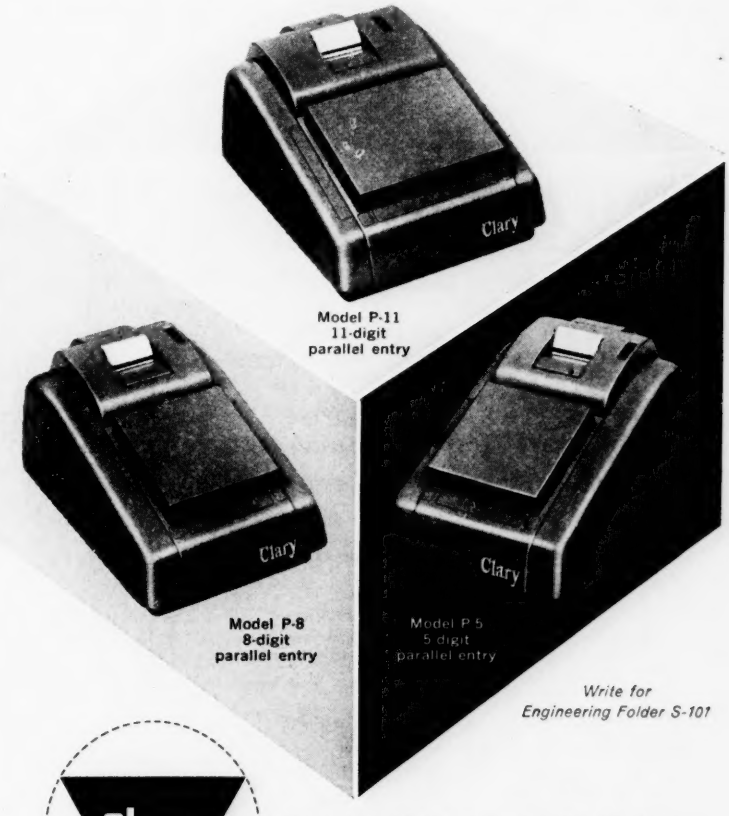

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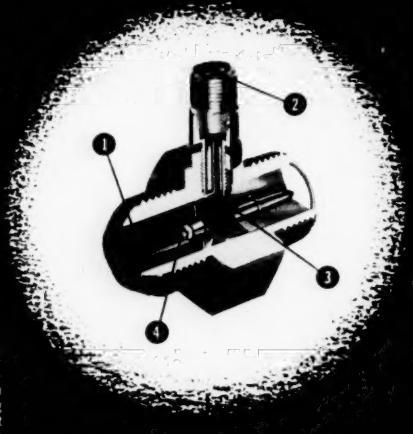
Helical rotor blades, advanced hydrodynamic design, allow minimum pressure loss in meter.



2 HIGH FREQUENCY OUTPUT

Each blade tip generates one electrical output cycle, providing a high frequency signal for improved resolution with electronic counters or for transient flow measurements.

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Light weight, low inertia rotor responds instantly to changes in flow rate, permitting accurate measurement of flow pulsations up to 50 per second.

4 EASY DISASSEMBLY

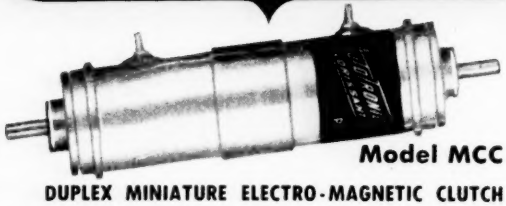
Rotor may be removed and reassembled quickly without effect on flowmeter calibration factor. Rugged construction permits intermittent use at double the normal rate of flow.

Write for Bulletin 101 for complete data

Waugh ENGINEERING CO. 7842 Burnet Ave., Van Nuys, Calif.

For more information circle **130** on inquiry card.

AUTOTRONICS *for precision control*



Model MCC

DUPLEX MINIATURE ELECTRO-MAGNETIC CLUTCH

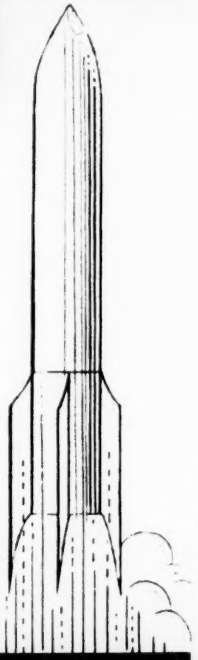
DE-ENERGIZED — both flanges as well as the output shaft are free running.

ENERGIZED — either coil engages its respective flange to the output shaft.

The function of the shafts may be reversed so that a single input can be connected to either of two output shafts.

The model MCC is available in four sizes and two standard shaft configurations, pilot diameters from .500" to 1.250", torque from 4 oz. in. to 56 oz. in.

Write for catalog 957
for data on all Autotronics standard clutch and brake units.



AUTOTRONICS INC. Box 812, Rt. 1, FLORISSANT, MISSOURI

For more information circle **131** on inquiry card.

electromechanical components

MINIATURE AC MOTOR

New Type 117 Form H permanent-magnet synchronous motor for instrumentation uses is rated 60 oz-in at 1 rpm; is offered in speeds from 72 to 2 rpm; features max rise of 35 C°; reaches synchronous speed within 2 cycles.—*Cramer Controls Corp., Centerbrook, Conn.*

For more information circle **432** on inquiry card.

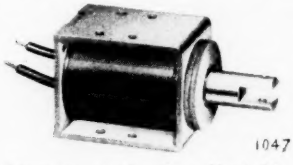
ACTUATOR MOTOR

New high-torque servomotor starts or stops in a split second, operates to 500° F; is basically a rotary solenoid whose vibrating rate (120 cps when operated on 60 cps ac) is translated into rotary stepping motion.—*Viking Tool & Machine Corp., 20 Main St., Belleville 9, N. J.*

For more information circle **433** on inquiry card.

POWER SOLENOID

New version of maker's standard No. 4 Solenoid, with ½" dia tapered plug and plunger, can "lift" up to 9



lb. Plunger stroke is adjustable to ¾".—*Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.*

For more information circle **434** on inquiry card.

REVERSIBLE SUB-FHP MOTOR

New RBC-2514 2-speed reversible sub-fractional-hp motor is available with basic speeds of 1800 to 3600

rpm and gear reductions from 3/1 to 3600/1.—*Holtzer-Cabot Motor Div., 125 Amory St., Boston 19, Mass.*

For more information circle **435** on inquiry card.

connectors, etc.

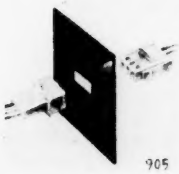
MINIATURE CONNECTORS

New "minniE" connectors are said to be the first miniatures fully conforming to "E" performance require-

ments of MIL-C-5015C; are available also in potting, cable clamp and jacketed cable types.—*Amphenol Electronics Corp., Chicago* 50, *Ill.*

For more information circle **436** on inquiry card.

MULTIPLE CONNECTOR



New Amp-lok for through-panel applications is said to obsolete other types of multiple connectors because it is self-anchoring and obviates need for supplementary mounting devices in through-panel applications; is polarized to eliminate circuit error; accommodates various panel thicknesses.—*AMP Inc., Harrisburg* 20, *Pa.*

For more information circle **437** on inquiry card.

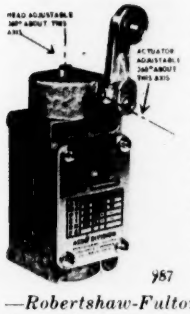
switches & relays

HI-TEMP SWITCH

New S9-4 provides precision tolerances over ambient temperature range of −100°F to 900°F; features ceramic case containing maker's standard switch mechanism for sp-dt 2-circuit electrical control; rating 5 amp 125/250 vac, 30 vdc ind.—*Electro Snap Switch & Mfg. Co.,* 4218 *W. Lake St., Chicago* 24, *Ill.*

For more information circle **438** on inquiry card.

MACHINE TOOL SWITCH



New precision limit switch can control as many as four separate circuits for pilot or line duty. Its actuation is adjustable in a full 360° sweep, on two different planes. Provisions have been made for easy replacement of rolling spring switch. —*Robertshaw-Fulton Controls Co., Acro Div., Columbus* 16, *Ohio.*

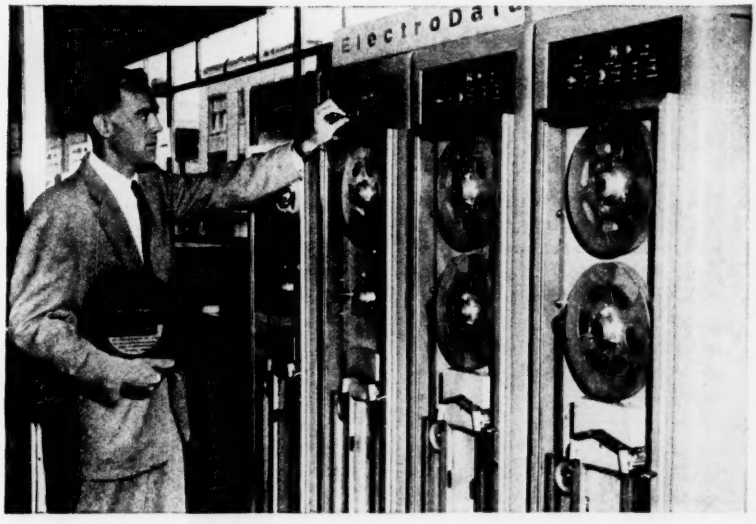
For more information circle **439** on inquiry card.

DUAL SEALED RELAY

New MH Seal Temp miniature high-temperature telephone type relay features a dual hermetic seal; relay

General Insurance of America tested

. . . *and picked* audiotape



Chief Engineer cites type EP Audiotape for "dust-free coating, uniform signal output . . . high precision"

WHEN General Insurance Company of America bought four Electrodata tape transports 18 months ago, they knew one thing: their computing system should have the finest magnetic recording tape available. It was decided that the best way to make the final decision was to test.

The tests started immediately. Every nationally known make of magnetic recording tape was used on the transports for at least a month. The result was clear; type EP Audiotape was chosen.

As D. G. Jessup, Chief Engineer of General's Computing Department, wrote in a letter to Audio Devices, "To obtain the optimum reliability and performance from our computing system we need the oxide dust-free coating, uniform signal output level correct in both directions of travel, and high precision reels which you supply. Keep up the good work!"

The extra precision Mr. Jessup found in type EP Audiotape is not a matter of chance. Rather it is the result of meticulous selection and inspections that start when the master rolls of base materials are examined for uniformity. The quality control is continued through the manufacturing process, ending only when the tape is checked by a defect counter, rejects discarded, and the defect-free tape packed in sealed containers. This high standard of control is backed up by our guarantee that every reel of type EP Audiotape is defect-free.

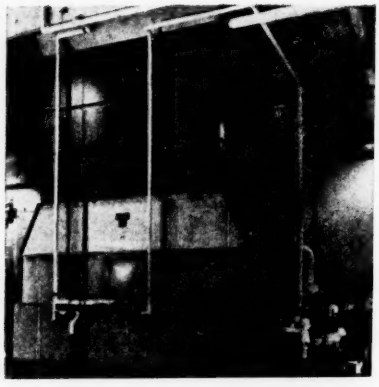
For more information on type EP AUDIOTAPE, write for Bulletin T112A. Write to Box TI, Audio Devices, 444 Madison Ave., New York 22, N. Y.

audiotape TRADE MARK

AUDIO DEVICES, INC., 444 Madison Ave., New York 22, N. Y.
Offices in Hollywood and Chicago
Export Dept.: 13 East 40th St., New York 16, N. Y.

For more information circle **132** on inquiry card.

WHEREVER YOU NEED TO COOL A FLUID... and have a problem of water supply or disposal... use NIAGARA "AERO" HEAT EXCHANGER



▶ Evaporating a very small amount of water in an air stream you can cool liquids, gases or vapors with atmospheric air, removing heat at the rate of input, controlling temperature precisely. Save 95% of the cost of cooling water; save piping, pumping and power. You quickly recover your equipment cost.

You can cool and hold accurately the temperature of all fluids, condense vapors, cool water, oils, solutions, intermediates, coolants for mechanical, electrical or thermal processes. You have a closed system free from dirt. You have solved all problems of water availability, quality or disposal, maintenance expense is low.

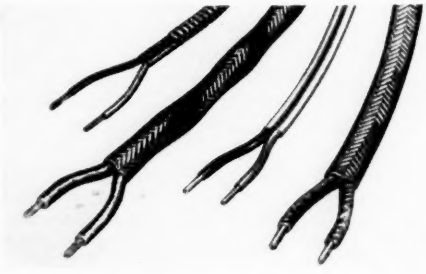
You may apply this to solvent recovery, vacuum systems controlling reactions, condensing distillates, cooling reflux products.

For more information, write for Bulletins 120, 124, 135. Address Dept. IN-1.

NIAGARA BLOWER COMPANY
Dept. IN-1, 405 Lexington Ave., New York 17, N. Y.
Niagara District Engineers in Principal Cities of U. S. and Canada
For more information circle **133** on inquiry card.

Thermocouple Wires

Quality • Variety • Delivery



Thermo Electric makes thermocouple and thermocouple extension wires for every possible use—actually over 1500 varieties. Just a few seconds with a T-E Wire Catalog will find the exact type you need. Solid and stranded conductors are available in all standard calibrations. The most modern types of insulations will meet all conditions of moisture, chemical action, abrasion and high temperature. Our own complete facilities for wire drawing, insulating and calibrating guarantee you unmatched quality. Prompt delivery on most types from our large stock.

Write for New Wire Catalog No. 32-F.

Thermo Electric Co. Inc.
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

For more information circle **134** on inquiry card.

NEW INSTRUMENTS

coil is sealed separately before sealing entire relay. This increases reliability, especially in 125°C ambient range, where outgassing organic coil materials may impair contact efficiency. Relay weighs about 5 oz; is $1\frac{13}{16}$" H by $1\frac{13}{16}$" D by $1\frac{15}{32}$" W; operates under 30 *G* shocks. Coil power requirements range from 100 mw per movable arm to 4 watts max at 25°C (200 mw minimum to meet maximum shock and vibration specs). Switching arrangements up to 4p-dt.—*Potter & Brumfield, Inc., Princeton, Ind.*

For more information circle **440** on inquiry card.

MIDGET RELAY FOR PRINTED CIRCUITS

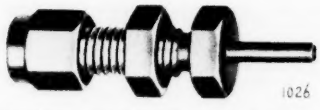
New Series GP was designed to fill need for a small general-purpose control relay that would rest solidly and firmly in a printed circuit board. Dimensions 1" W, $1\frac{1}{4}$" L, $1\frac{3}{4}$" H. Coils are available in all standard ac and dc voltages to 115. Contacts are self-wiping $\frac{1}{8}$" fine silver rated 5 amp.—*Hillburn Electronic Products Co., 55 Nassau Ave., Brooklyn 22, N. Y.*

For more information circle **441** on inquiry card.

mechanical components

BULKHEAD TUBE FITTING

New Swagelok Bulkhead Adapter can be readily installed for any desired combination of tube connections,

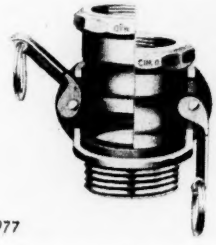


therefore speeds up and simplifies panel-board installations or bulkhead connections.—*Crawford Fitting Co., 884 E. 140 St., Cleveland 10, Ohio.*

For more information circle **442** on inquiry card.

QUICK CONNECT COUPLERS

New 6" size Kamloks (for fluid or powered-solid services) are available

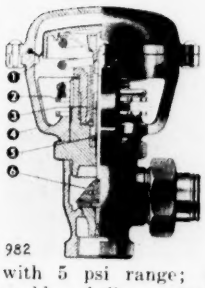


in aluminum and bronze, for hoses, piping, and equipment.—*Jordan Corp., 6013 Wiehe Road, Cincinnati 13, Ohio.*

For more information circle **443** on inquiry card.

valves, actuators

PACKLESS VALVE

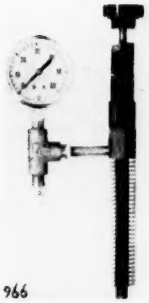


982

New Powertop packless valve features (1) 10-sq-in silicone diaphragm providing 60% greater closing power than previous models; (2) externally adjustable spring with 5 psi range; (3) heavy-duty packless bellows; (4) lower housing of high-impact phenolic; (5) neoprene quad ring secondary seal; (6) buna N disc suitable for steam and water up to 250 F (15 psi steam).—*The Powers Regulator Co., 3434 Oakton St., Skokie, Ill.*

For more information circle **444** on inquiry card.

VAPORIZING VALVE



966

New Model I Vaporizing Valve permits controlled expansion of condensable vapors with volume expansions up to several thousand to one. Condensation is minimized or prevented. Radial input aperture is controllable in microinches. Units with electric heaters and for automatic control are also available.—*Manufacturers Engineering & Equipment Corp., York Road & Sunset Lane, Hatboro, Pa.*

For more information circle **445** on inquiry card.

PINCH TYPE VALVES

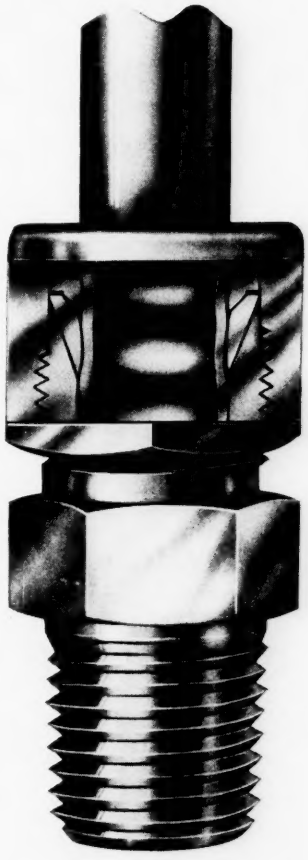
New Series G valves have no moving parts; are maintenance-free. Hydraulic or air pressure collapses flexible insert on itself to give tight shut-

1470

off on powders, acids or slurries. Natural or artificial rubber inserts; sizes 1" to 8".—*RKL Valve & Mfg. Co., Rt. 38 & Rudderow Ave., Maple Shade, N. J.*

For more information circle **446** on inquiry card.

torque-free leakproof seal



★

easily installed

★

engineered to meet the most exacting specifications

★

available in any machinable metal or plastic

★

Swagelok®

TUBE FITTINGS

For information on the extensive line of Swagelok Tube Fittings that provide a true torque-free leakproof seal and the name of your Swagelok Specialist, write Dept. BI

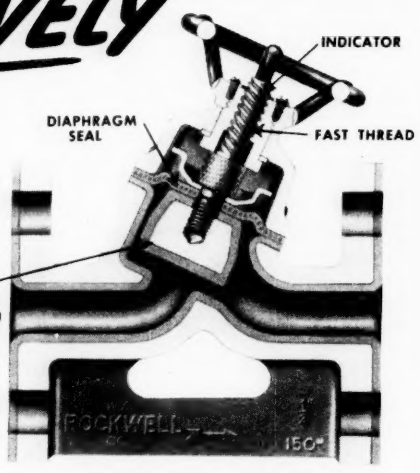
CRAWFORD FITTING COMPANY

884 East 140th Street • Cleveland 10, Ohio

For more information circle **135** on inquiry card.

CLOSES and SEALS *POSITIVELY*

"D-D" Diaphragm Valve



Disc for Positive Closure
Diaphragm for Positive Sealing

Ideal for corrosive, hazardous or delicate liquids and slurries; water, air, gas; vacuum service.

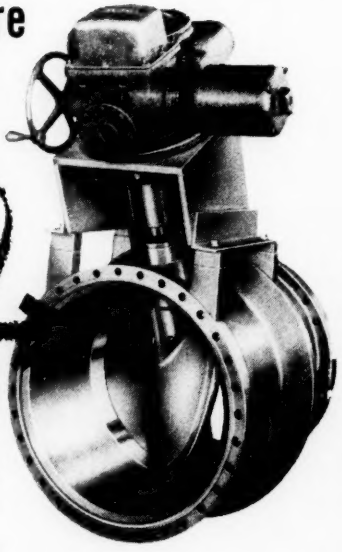
- No packing gland to leak. Mechanism not exposed.
- Oversized ports; high capacity; low pressure drop. Largest capacity of any diaphragm type valve.
- Self-draining in horizontal position.
- Lower handwheel torque and fewer turns to close.
- Lower thrust for automatic operation.
- Body of any metal or with any lining.
- Sizes ½" to 6".

Write for Bulletin.

for Throttling and Shut-Off

at HIGH Temperature and HIGH Pressure

Stress Sealed Butterfly Valve



Costs Less — Saves Space

Unique W. S. Rockwell pressure sealing arrangement enables disc to seat full 360° against inflated alloy band in valve body, practically eliminating leakage of gases even at 800° F. or higher and at pressure to 250 psi.

Illustrated is a 30" valve with motor operator; other sizes to 132".

W. S. ROCKWELL COMPANY
2128 ELIOT STREET • FAIRFIELD, CONN.
Sales Representatives in Principal Cities

For more information circle **136** on inquiry card.

miscellaneous

DEMINERALIZER

New Penfield Mono-Column Demineralizer features cast acrylic columns for both carbon-filter column and ion-exchange column; operates on mixed-bed ion-exchange principles; produces up to 100 gph of ultra-pure (less than 0.5 ppm) tasteless and odor-free water. Plexiglas columns enable operator to see action in both columns at all times. Controls for fully automatic operation are optional equipment.—*Penfield Mfg. Co.*, 19 *High School Ave., Meriden, Conn.*

For more information circle **447** on inquiry card.

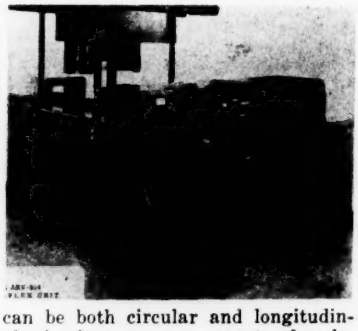
OIL SEPARATOR

New Model A, for use in plant streams and in spot checking, removes oil from gas streams down to microscopic quantities; prevents pickup and buildup of oil by gas. Oil is drained down a wick to a reservoir in bottom. Other features making for high efficiency: (1) large effective path of gas passing through unit, as compared to size of unit itself; (2) maintenance of intimate contact of gas with condensing surfaces throughout its path—*Manufacturers Engineering & Equipment Corp., York Rd. & Sunset Lane, Hatboro, Pa.*

For more information circle **448** on inquiry card.

MAGNETIC INSPECTOR

New Type ARV-304 Magnaglo unit provides increased automatic production inspection. Magnetization

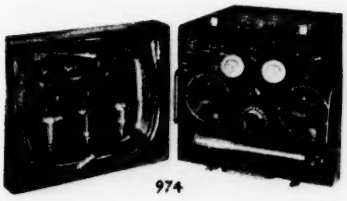


can be both circular and longitudinal, simultaneous or separate, for detection of both longitudinal and transverse defects. It permits addition of a conveyorized inspection unit to speed inspection and provide automatic demagnetization.—*Magnaflux Corp.*, 7300 *W. Lawrence Ave., Chicago* 31, *Ill.*

For more information circle **449** on inquiry card.

AIRSPEED AND ALTITUDE FIELD TEST SET

New test set for flight line testing of aircraft pressure instruments and systems simulates two types of tem-



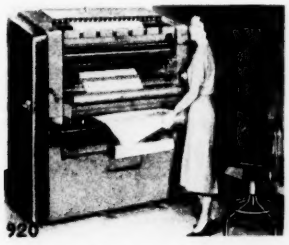
974

perature probes and generates selected Pitot and static pressures.—*Norden-Ketay Corp., Commerce Road, Stamford, Conn.*

For more information circle **450** on inquiry card.

WHITEPRINTER

New Copyflex 575 high-speed whiteprinter with an extremely wide printing latitude features 5000- to



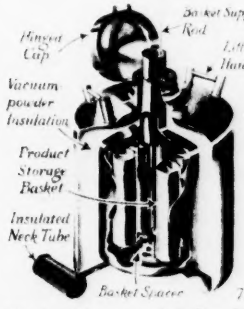
920

7500-watt selective-switch-controlled lamp, adjustable lamp shield, speed of 75 fpm, and 46" printing width; is said to increase average print production as much as 250%.—*Charles Bruning Co., Inc., 4700 W. Montrose Ave., Chicago 41, Ill.*

For more information circle **451** on inquiry card.

PORTABLE LIQUID NITROGEN REFRIGERATOR

New LNR-25B has inner container filled with liquid nitrogen at −320° F, into which accessory storage bas-



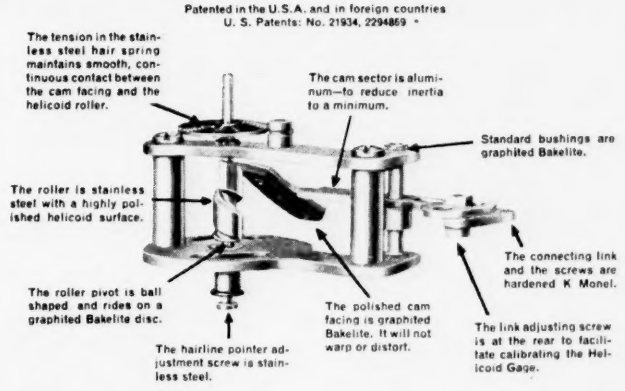
kets filled with material for freezing or cold storage are lowered. A single charge of liquid nitrogen will hold up to 34 days.—*Linde Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y.*

For more information circle **452** on inquiry card.

ACCO Helicoid Gage U.S.A.

Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

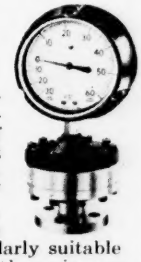
These details of Helicoid gage design assure longer life and enduring accuracy


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

The Chemical Gage



The Helicoid Chemical Gage has a guaranteed accuracy of plus or minus 1%. It is applicable for working pressures from 30" vacuum to 5000 p.s.i. and temperatures to 400° F. It is particularly suitable for chemicals and other viscous fluids which might clog or corrode a Bourdon tube. Pressure and or vacuum is transmitted directly to the indicating gage element through deflection of a Teflon or Kel F sealing diaphragm.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials—alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

Helicoid gives you all these features at prices that are competitive in the quality gage field.

Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-B Connecticut Avenue • Bridgeport 2, Connecticut

ACCO TRADE MARK

For more information circle **137** on inquiry card.

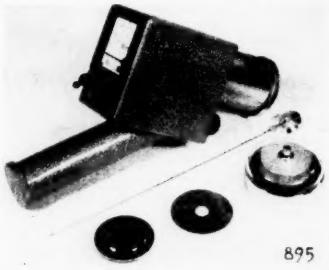
BATTERY CHARGERS

New Bulletin 203 Industrial Type Battery Chargers can be equipped with modified features: high-low toggle switch for manual selection of charging rate; also a charging disconnect relay and reset timer. When battery is low, combination automatically charges battery at a high rate for a fixed period, after which battery charger is automatically reset to a trickle charge. Outputs 6, 12, 24, 32 vdc with charging rate of 0.05 to 2.0 amp (continuous adjustment). —*Automatic Switch Co., Florham Park, N. J.*

For more information circle **453** on inquiry card.

STATIC DETECTOR

New Statometer is a new type of instrument for detecting and measur-

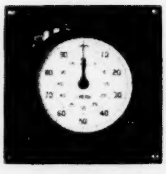


895

precision timers by... STANDARD TRADEMARK

Industry's preferred "instrument of a thousand uses". Accurate, rugged, versatile STANDARD Elapsed Time Indicators. Synchronous motor drive. Electric clutch controlled by manual or automatic switch or output of electronic tubes. Manual or electric zero reset. Units for flush panel mounting or portable use.

Model	Scale Divisions	Totalizes	Accuracy
S-100	1/5 sec.	6000 sec.	±.1 sec.
S-60	1/5 sec.	60 min.	±.1 sec.
SM-60	1/100 min.	60 min.	±.002 min.
S-10	1/10 sec.	1000 sec.	±.02 sec.
S-6	1/1000 min.	10 min.	±.0002 min.
S-1	1/100 sec.	60 sec.	±.01 sec.
MST	1/1000 sec.	.360 sec.	±.001 sec.
MST-500	1/1000 sec.	30 sec.	±.002 sec.



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ing static electricity charges (range 0 to 500,000 v); eliminates costly shutdowns since it not only indicates existence of static but also pinpoints area of disturbance, enabling installation of appropriate static eliminators. —*United States Radium Corp., Morristown, N. J.*

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LAST-MINUTE ITEMS

Brushless Alternator with no moving part except a solid metal rotor is especially suitable for work at 800°F and above in air or ground applications; ratings from 0.5 to 125 kva.—Aerojet-General, Azusa, Calif.

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Degausser. New No. 9205-A erases program material and residual noise from mag tape and film; was designed for industrial use with heavy-duty double fuse and d-p switch.—Cinema-Aerovox, 1100 Chestnut St., Burbank, Calif.

For more information circle **456** on inquiry card.

Dual-speed Tape Recorder. New Knight KN-4010 has a wide variety of applications in business and industry.—Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.

For more information circle **457** on inquiry card.

pH Kit for Multi-station Use includes 5 portable instruments with carrying cases and buffer solutions, 2 buffer kits, 2 extra probes and 2 sets of batteries.—Analytical Measurements, Inc., Chatham, N. J.

For more information circle **458** on inquiry card.

Solenoid-operated Drain Valve. New Bulletin 8339 direct-acting type has excellent draining characteristics and its quick clean-out plug obviates messy maintenance.—Automatic Switch Co., Florham Park, N. J.

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Cooling Effect Detection and Control Systems can be made to switch from ram-air to refrigerated-air cooling, to control turbine-bypass or airflow throttling valves, or to act as a warning or shutdown.—Barber-Colman Co., Aircraft Controls Div., 1400 Rock St., Rockford, Ill.

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Lab Sterilizer, hinged-door type with full opening to accommodate large trays, can be supplied with control unit for complete automatic sterilizing cycle.—Barnstead Still & Sterilizer Co., 244 Lanesville Terrace, Boston 31, Mass.

For more information circle **461** on inquiry card.

35mm Camera. New Royal Super features improved viewfinder, high-speed coated f/2.8, 50mm Tominor needle-sharp 5-element lens.—Burke & James, Inc., 321 S. Wabash Ave., Chicago 4, Ill.

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Temperature-pressure Relief Valve. New Type F-3T for water heaters features advanced design which permits fuse plug replacement without

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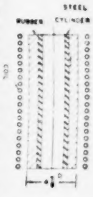
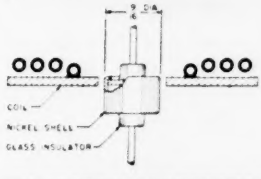


Induction heating develops uniform temperature at steel-rubber interface destroying bond for easy separation. Steel and rubber may similarly be salvaged from mounting brackets, shock absorbers, etc.



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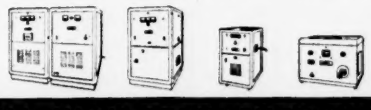

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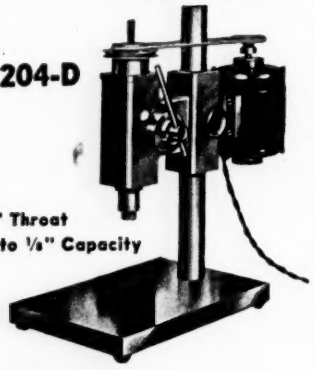

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NEW INSTRUMENTS

disturbing valve's installation.—Cash-Acme, P. O. Box 191, Decatur, Ill.
For more information circle **463** on inquiry card.

Vacuum Gage. New Type GP-115 single-station Pirani gage with a contact meter has two scales: 0 to 2000 microns Hg with 50 microns lowest division, and 0-50 micron with one-micron graduations. New type of sensing tube minimizes zero drift.—Consolidated Electrodynamics Corp., Rochester Div., 1775 Mt. Read Blvd., Rochester 3, N. Y.
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Turbine Safety Valve. New model of standard Reheat Header Spring Loaded Safety Valve has an added feature for protection against overspeed of low-pressure turbine in case of failure of intercept valve to close on loss of turbine load.—Crosby Valve & Gage Co., Wrentham, Mass.
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Culture Apparatus. New Chemostat continuous culture apparatus for micro-organisms can be furnished with a glass feeder and growth tube or as a complete assembly ready to operate.—Delmar Scientific Labs., 4701 W. Grand Ave., Chicago 39, Ill.
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Nameplates in quantities of one at low unit cost can be obtained custom-imprinted with any wording supplied by customer.—The Henry G. Dietz Co., 12-16 Astoria Blvd., Long Island City 2, N. Y.
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Small Stroke Counter. New Model 4-X-1-1 for equipment and machinery application features unusual strength and rigidity, is sealed against dust and moisture.—Durant Mfg. Co., 1914 N. Buffum St., Milwaukee 1, Wis.
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Motor Alternator. New high-precision Model MA-3, in compact package, meets rigid MIL specs; wide variety of possible combinations, developing both 90- and 150-cps outputs from a 400-cps input.—Eastern Air Devices, Inc., 385 Central Ave., Dover, N. H.
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DC Hour Meter to fit existing panel mounting holes features reduced unwind time, has a longer life expectancy owing to its low power consumption.—Engler Instrument Co., 250 Culver Ave., Jersey City 5, N. J.
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heads can be installed in a small space (2" to 12" apart) or on one side of object to be scanned.—Farmer Electric Products Co., 2300 Washington St., Newton Lower Falls, Mass.
For more information circle **472** on inquiry card.

Dc Contactors and Relays enable major inventory reductions; 100 or more different types from as few as 12 building-block components: unit-mounted mill contactors rated 100-900 amp; unmounted mill contactors rated 100-2500 amp; dc relays with 1 to 12 circuits; timing relays from 0.25 to 5 sec.—General Electric Co., Schenectady 5, N. Y.
For more information circle **473** on inquiry card.

Meter Contacts. New style contact devices, designed especially for use with V-60 polyphase meters, include new D31V with relay amplifier, also D20V and D30V which replace older D-12 and D-5.—General Electric Co., Schenectady 5, N. Y.
For more information circle **474** on inquiry card.

High-power Silicon Rectifier Stacks save space in military and commercial equipment; withstand the most severe environmental conditions; operate successfully at ambient temperatures from −50°C to 165°C and can be stored at from −65°C to 180°C.—General Instrument Corp., Automatic Mfg. Div., 65 Gouverneur St., Newark 4, N. J.
For more information circle **475** on inquiry card.

Socket designed for use with new 3- and 4-pin Jetec 30 transistors has body molded from mica-filled phenolic per MIL-M-14 type MFE; wrap-around silver-plated gold-flashed Be-Cu contacts.—Grayhill, Inc., 561 Hillgrove Ave., LaGrange, Ill.
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Time Delay Relays, subminiature, hermetically-sealed for aircraft, missiles and rockets; settings from 1 sec to 2 hr with dc motors and from 25 sec to 3 hr with 400-cps ac motor.—A. W. Haydon Co., Waterbury, Conn.
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For more information circle **478** on inquiry card.

Silicon Diodes. New cartridge type rectifiers rated at 100 ma rectified dc output with PIV's of 1500 to 2400 operate at ambient temperatures from −55°C to 150°C.—International Rectifier Corp., El Segundo, Calif.
For more information circle **479** on inquiry card.

High-voltage Selenium Rectifiers feature 73 to 100% increase in voltage rating over standard 26-v cell, hence only half the number of 52-v cells per stack; also about one-half leakage current at 52-v that standard cells are permitted at 26 v. Now avail-

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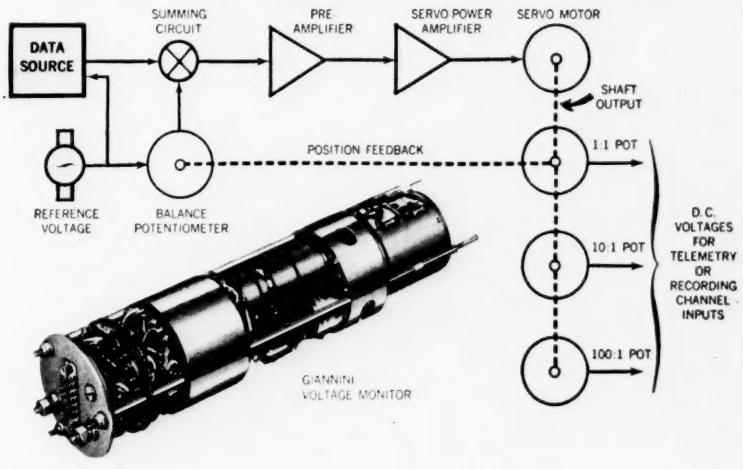

GIANNINI PRECISION VOLTAGE MONITORS are Data Repeaters which utilize the scale multiplying technique. They have an inherent accuracy of 0.035% under all conditions, and repeatability of one part in ten thousand. This is the first time that such accuracy has been possible in a small (2¼" x 9") unit capable of withstanding the extreme environments of airborne operation.

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A VOLTAGE MONITOR CONVERTS AC output signals from an airborne data source into 3 DC voltages, representing the data to four or more significant figures. These three separate units of information are fed into the telemetering or recording system on three separate channels. The result is transmitted information with an accuracy of four or five significant figures.

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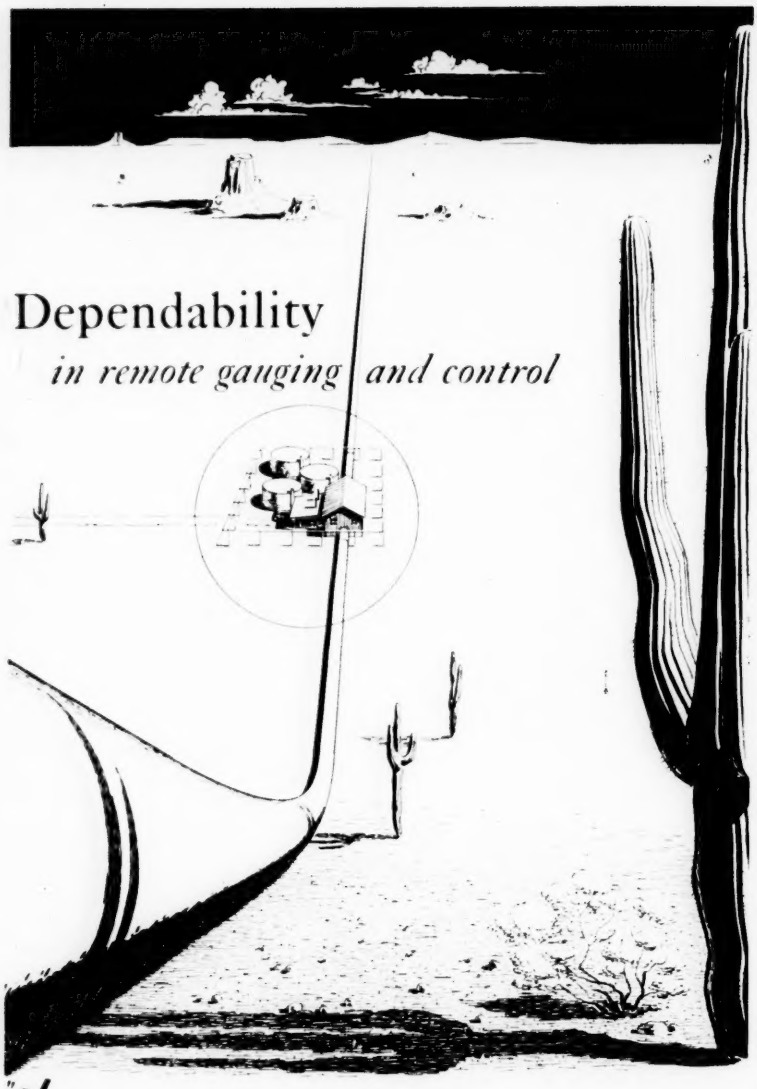

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NEW INSTRUMENTS

able in plate sizes from 1"x1" to 4"x4".—International Rectifier Corp., El Segundo, Calif.

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200-amp Silicon Rectifier Junctions feature exceptional shock resistance, mechanical design that integrates junction and heat exchanger into one small package; hermetic sealing within corrosion-resistant anodized-cast-aluminum housing, for mining, machine tool and other industrial fields.—International Rectifier Corp., El Segundo, Calif.

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Ferrite Isolator. New Model W177-5C-1 Transverse Field Ferrite Isolator operates over frequency range of 8.2 to 12.4 kMc, can handle an average power of 100 w; insertion loss 1.3 db max over entire range.—Kearfott Co., Inc., Western Div., 14844 Oxnard St., Van Nuys, Calif.

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Electric Furnace. New Atmo-Carb controlled-atmosphere furnace will sell for less with atmosphere generator and Inconel muffle than an atmosphere generator alone generally sells for; available in 4½x5½x8", 8x6x14" and 8x6x18" firing chamber sizes.—L & L Mfg. Co., 136 Eighth St., Upland 73, Pa.

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Salt Bath Furnace. New Series 2055 comes complete with controls; prevents oxidation, scaling and decarburization while operating at peak production with unskilled labor. Ten sizes; ranges to 1700°F.—Lucifer Furnaces, Inc., Neshaminy, Pa.

For more information circle **484** on inquiry card.

Solder Alloy. New Savbit makes copper tips last ten times longer. Available 5-core solder containing non-corrosive extra-fast Ersin Flux, in 14, 16 and 18 gage. Melting point and electrical conductivity about same as of normal tin/lead alloys. Strength of Savbit slightly greater.—Multicore Sales Corp., Port Washington, N. Y.

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Water Bath. General-purpose serological Model 8725 features thermometer holder, adjustable rack to 5" or 7" depth, hydraulic thermostat with temperature range to 100°C.—National Appliance Co., 7634 S. W. Capitol Highway, Portland, Oregon.

For more information circle **486** on inquiry card.

Power Supplies. Models KM75 and KM81 Aircraft Battery Substitutes now deliver 0-32 vdc @ 5 and 10 amp respectively; max rms ripple 0.5% at full load. Revised designs for portable or bench use.—Opad Electric Co., 69 Murray St., New York 7, N. Y.

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Power Supply for Airfields, etc. New transistorized Magamp delivers 27 to 42 v @ 0 to 300 amp, regulated at load which can be located several hundred feet away. Surge capacity 400% overload for 2 sec. Cabinet

size 22"x22"x48" high.—Packard-Bell Electronics, 12333 W. Olympic Blvd., Los Angeles 64, Calif.

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Mag-amp-reg VR. New Model MIR-3000 3-KVA tubeless ac line voltage regulator contains no moving parts or vibrating contacts. Input range 95-135 v; output adjustable from 110 to 120 v. Regulation 0.5%.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

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25-kw Silicon Power Supply. New Model S125-200 delivers 125 vdc nominal @ 200 amp (or 250 v @ 100 amp), with ac input of 208, 230 or 460 v 60 cps 3-phase.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

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Exposure Meter. Original Model A has been improved and is marketed under registered trade name of Spectra Professional; features instant direct reading with great accuracy.—Photo Research Corp., 837 No. Cahuenga Blvd., Hollywood 38, Calif.

For more information circle **491** on inquiry card.

Spur Gear Kits. New Type CT kits made up of AGMA Precision I, II, or III gears in stainless steel or aluminum are available in 48, 64, 72, 96, and 120 pitches, come in felt-lined cases.—PIC Design Corp., 477 Atlantic Ave., E. Rockaway, N. Y.

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Counting-device Booster. New SD-1 unit increases life and speed range of electromechanical registers as much as 15 times; can be placed several hundred feet from switch contacts; registers in counts of 10 while counting up to 50 units per second.—Post Electronic Products Div., Beverly, Mass.

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Clogged Air Cleaner Alarm. New vacuum switch signals reduction of manifold air pressure, is primarily for gasoline- and diesel-engine-powered equipment which uses positive-type paper-element air cleaner; would be equally suitable for industrial equipment where a vacuum change signal is desired.—Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Box 400, Knoxville 1, Tenn.

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Extra-heavy-duty Flexible Shaft features new 1¼" core made up of layers of tightly-wound high-grade music wire; can transmit 1650 lb-in torque at 440 rpm; is believed to be "the strongest power drive flexible shaft in the world."—Stow Mfg. Co., 25 Shear St., Binghamton, N. Y.

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Time-Mark Generator. Type RM181 generates five time markers: 1, 10, 100, 1000, and 10,000 usec, and a 10-Mc sine wave, derived from a 1-Mc crystal-controlled oscillator. Output amplitude about 2v. Also available with a temperature-stabilized crystal oven: frequency stability 2 ppm over 24 hours.—Tektronix, Inc., P. O. Box 831, Portland 7, Oregon.

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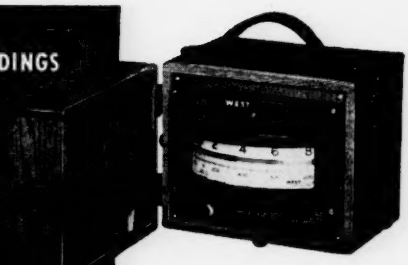

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new plants and mergers

Beckman

BECKMAN INSTRUMENTS is constructing a $250,000 plant in Scotland for the company's new subsidiary, Beckman Instruments, Ltd.

CONSOLIDATED AVIONICS, subsidiary of Consolidated Diesel Electric, will occupy a new 20,000 sq. ft. plant and office at Westbury Industrial Park.

MINNEAPOLIS-HONEYWELL'S HEILAND DIV., has enlarged production and engineering facilities by 12,000 sq. ft.

MIDWESTERN INSTRUMENTS has purchased total assets of Data Storage Devices Co., which will be operated as a separate division in Tulsa.

AUDIO DEVICES announces creation of a new manufacturing division to produce silicon rectifiers.

INTERNATIONAL BUSINESS MACHINES, Supplies Div., soon will begin operations at its newly-built punch-card plant in Texas.

SERVOMECHANISMS' Canadian subsidiary signed contracts implementing licensing of a Japanese firm to manufacture certain airborne computing units.

panel mounted Pyrometers with *Alnor*® *Accuracy*

Alnor Pyrometers are designed to give consistently accurate temperature readings under the most severe conditions of vibration, dirt and corrosive atmosphere. Sturdy, laboratory-precise movements are cushioned in fume-proof, splash-proof welded steel cases in front of board or flush type mountings. Six series available for single circuit up to 31 circuit applications. Eleven standard ranges covering 0-300° F. to 0-3000° F. or centigrade equivalents.

Single-circuit series data is covered in Bulletin 4371.

Multi-circuit series data covered in Bulletin 4361.

Circle number you wish; attach this ad to your letterhead, and mail to: Illinois Testing Laboratories, Inc., Room **518,** 420 N. LaSalle St., Chicago 10, Ill.

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Alnor

For more information circle **152** on inquiry card.

DEHYDRATION OF GASES

HI-LO PRESSURES

HI-LO FLOWS

"PAT PEND"

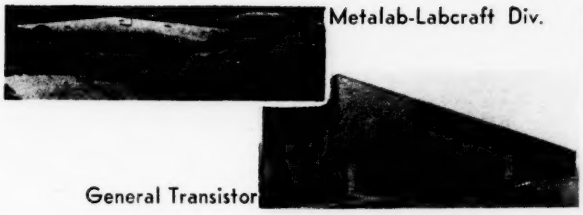
- New Leakproof Design — Chambers and Cartridges "O" Ring sealed, no possibility of gas bypassing the cartridge.
- No tools required to change cartride or Mechanical Filter Element for cleaning.
- Manual or Automatic Units. Portable, stationary or airborne installations.

ROBBINS AVIATION

WRITE FOR BULLETIN

1735 W. FLORENCE AVE. LOS ANGELES 47, CALIF.

For more information circle **153** on inquiry card.



NORBUTE CORP. which just opened an ultra-modern facility, METALAB-LABCRAFT DIV., at Elkins, W. Va., has elected *Howard M. Plant* chairman of the board.

GENERAL TRANSISTOR has leased an additional 16,000 sq ft building at Richmond Hill, N. Y.

CANNON ELECTRIC CO., California Div., soon plans erection of a new $1¼ million, 106,000 sq. ft. facility.

MINIATURE PRECISION BEARINGS, Inc., has broken ground for a new $350,000 plant in Lebanon, N. H., to house the recently acquired Split Ballbearing Division.

ELGIN NATIONAL WATCH Company's Micronics Division-West Coast recently moved its new R & D facilities into a 20,000-sq-ft plant in Chatsworth.

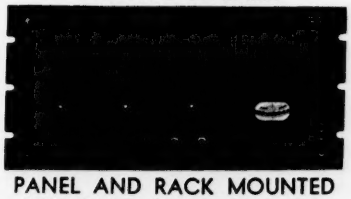
CUBIC CORP., San Diego, Calif., has acquired Digital, Inc., an electronic firm of the same city.

MAGNETIC RESEARCH CORP. announces formation of the new Stablvolt Div. for the manufacture of a new line of d-c power supplies and related equipment.

ANATRAN CORP., organized to take over operations of the former Anatran Div. of Endevco Corp., has moved into new headquarters in Pasadena.

GRAY FOR ACCURACY .1 TO .01%

VOLTAGE DIVIDERS



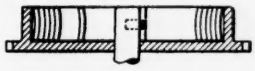
PANEL AND RACK MOUNTED
STANDARD OR SPECIAL, TO
YOUR SPECIFICATIONS

SYNCHRO BRIDGES
TRANSMITTER & RESOLVER BRIDGES
2½°, 5°, 10° & 15° INTERVALS
EQUAL AND LINEAR TO .005%
SEND FOR OUR CATLOG

GRAY INSTRUMENT COMPANY
PHILADELPHIA 44, PA.

For more information circle **154** on inquiry card.

Sandsteel's *Crosscurving* **in a spring**



improves product performance

Sandsteel's unique *crosscurving* process gives its springs an unusual concave-convex construction which tends to release power evenly, smoothly... while containing vast reserves. Those plus factors, in addition to *crosscurving's* demand for highest grade steel (Sandsteel uses finest Swedish) assure long life, efficient performance.
Next time, use Sandsteel Mainsprings.

Write for FREE LITERATURE and CASE FILE. Dept. PD

SANDVIK STEEL, INC.
SANDSTEEL SPRING DIVISION
FAIR LAWN, NEW JERSEY
88-153

For more information circle **155** on inquiry card.

NEW

DWYER FLEX-TUBE Series 25

THE
MANOMETER
THAT

- ***COSTS HALF as much***
- ***Is only HALF as BIG***
- ***IS ACCURATE to 3%***
- ***Does 4 NEEDED JOBS***

and is practically indestructible!

Only 7⅜" wide, 5¾" high and 1½" deep. Housing and tube of tough Tenite II plastic. Logarithmic indicating tube for accurate and easy reading. Two ranges: 0-3" and 0-7". Gages (1) static pressure, (2) draft, (3) filter resistance and (4) velocity from 0-7000 fpm. (with pitot tube).

A complete "package". Unit includes all necessary connector tubing and fittings, mounting screws, fluid, instructions.

Write for informative catalog page

DWYER
Specialized **INSTRUMENTS and GAGES**

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For more information circle **156** on inquiry card.

the standard for its service . .

ESCO TYPE-A ROTARY MULTIPOLE SWITCH

RATINGS:

Continuous
10 amp. 125 volts

Interrupting
AC—5 amp. 125 volts (at 0.75 PF)
3 amp. 125 volts (lamp load)
DC—5 amp. 30 volts (non-inductive load)
1 amp. 125 volts

Overload
50 cycles—30 amp. 125 volts (non-inductive load)

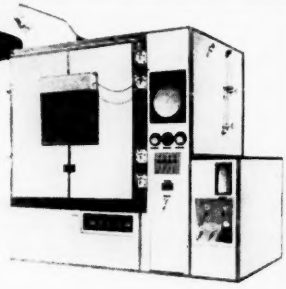
A compact, multipole switch for tap, transfer, and selector service at medium current ratings. Up to seven sections controlled from a single knob. Wide selection of switching actions. An exceptionally sturdy detent assures positive positioning at all steps. *Write for FREE descriptive bulletin.*

ESCO *of* WEYMOUTH
ELECTRO SWITCH CORPORATION
Weymouth 88, Massachusetts

For more information circle **157** on inquiry card.

DEVELCO

SALT SPRAY FOG TEST CHAMBER



To meet MIL-E-5272 and others.

TOP OPENING
FRONT OPENING
WALK-IN

Write for Bulletin SS-55

DEVELCO

DEVELOPMENT ENGINEERING COMPANY

9 Cross Street • Norwalk, Connecticut

• ***Manufacturers of Environmental Test Equipment***
Fungus Testing - Cold - Heat - Altitude - Humidity

For more information circle **158** on inquiry card.

people in the news

M. L. Klein

J. P. Baker

Van Zandt Williams

COHU ELECTRONICS has named *Martin L. Klein* head of the newly-formed Research Div. and *R. T. Silberman* president of the Kin Tel Div.

MAGNETIC RESEARCH CORP. has appointed *J. P. Baker* national sales manager.

PERKIN-ELMER CORP. has named *Dr. Van Zandt Williams* executive vice president.

ROBERTSHAW-FULTON CONTROLS CO. has appointed *H. Clay Oliver* general superintendent of Fulton Sylphon Div.

OPTICAL COATING LABORATORY, INC., has appointed *Rob Roy Cyr* to newly created post of vacuum equipment sales manager.

BJ ELECTRONICS, BORG-WARNER CORP., has named *Clifford B. Smith* as sales manager.

Whether it is production quantities of high precision accuracy or elements of non-critical requirements.

Plummer & Kershaw have AUTOMATIZED their production facilities that enables the mass production of non-critical elements of the highest quality.

Combining the use of AUTOMATIZED equipment with hand operations, result in the close accuracy of the high precision elements for which PLUMMER & KERSHAW have established their enviable reputation of highest accuracy and quality at lowest cost, and of course meeting your delivery requirements.

Request Bulletin 737
On your Letterhead.

PLUMMER and KERSHAW

2759 Frankford Ave., Philadelphia 34, Pa.

For more information circle **159** on inquiry card.

T. S. Mederos

J. F. Degen

C. T. Cosser

ASCOP (Applied Science Corp. of Princeton) announces appointment of *Thomas S. Mederos* as sales assistant to the president, and of *Robert E. Navin* as manager of the Instrumentation Division to succeed Mr. Mederos.

WESTON ELECTRICAL INSTRUMENT CORP., a Daystrom, Inc. division, has appointed *Joseph F. Degen* vice president in charge of manufacturing.

CLARY DYNAMICS DIV., CLARY CORP., has appointed *Charles T. Cosser* general sales manager.

W. A. KATES CO. has appointed *Fred B. Miller* sales manager.

WAUGH ENGINEERING has appointed *Kenneth R. Jackson* special assistant to the president.

K. R. Jackson

F. B. Miller

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SEPULVEDA CALIFORNIA

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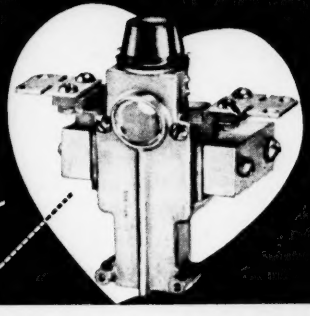
For more information circle 161 on inquiry card.

Make a GM PORTABLE D'ARSONVAL

GALVANOMETER

the Heart of Your Instrument



IN THE AUTOMOTIVE FIELD, the Bear Manufacturing Co. of Rock Island, Ill. uses Series 500 G-M Galvanometers in its new remote-reading Electric Wheel Alignment System (left). Whatever your own particular instrument field, you can achieve this same self-contained portability, ruggedness and high sensitivity with G-M Galvanometers. Complete catalog on request.

GM LABORATORIES • INC.

4316 NORTH KNOX AVE., CHICAGO 41

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SINGLE COIL

IMPULSE LATCHING RELAY

new!

ONE-COIL ECONOMY
TWO-COIL EFFICIENCY
plus
COMPACTNESS

● Features an insulated rocker arm activated by a single coil, instead of the usual two. Ideal for machine controls, appliances, positioning devices, remote TV controls and other applications where opposite switching is desired each time the circuit is pulsed. Contact combinations up to 4 "C"; rated 7½ amperes @ 115 V. AC resistive.

Send for Bulletin W

Comar ELECTRIC COMPANY

3349 ADDISON ST., CHICAGO 18, ILLINOIS

RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

For more information circle 162 on inquiry card.

new literature

AUTOMATION

PHOTOELECTRIC CONTROLS. 2-page Bulletin PA 579 describes new long-range systems using infrared beam.—Photoswitch Div., Electronics Corp. of America, 77 Broadway, Cambridge, Mass.

Circle **501** on inquiry card.

PNEUMATIC CONTROLLERS. 12-page Catalog 53P-4000 discusses motion-balance pneumatic controllers with exclusive regenerative feedback circuit.—Fischer & Porter Co., 489 Jacksonville Rd., Hatboro, Penna.

Circle **502** on inquiry card.

PRODUCTION CONTROL through automation is described in illustrated 12-page brochure.—Patterson-Emerson-Comstock, Inc., Automation Div., 313 E. Carson St., Pittsburgh 19, Pa.

Circle **503** on inquiry card.

AUTOMATIC CONTROLLER. 4-page Specification Folio 57-2 describes Type VC Pneumatic Controller for use with featuring proportional band adjustable from 2% to 500% and reset rate adjustable from 0.1 to 50 r/m.—Republic Flow Meters Co., Subs. of Rockwell Mfg. Co., 2240 Diversey Parkway, Chicago 47, Ill.

Circle **504** on inquiry card.

ELECTRICAL CONTROLS. 12-page Bulletin 106 describes new Versatrols, meter-relay-type instruments suitable for use with virtually any detectable variable.—Assembly Products, Inc., Chesterland, Ohio.

Circle **505** on inquiry card.

CONTACT-TYPE CONTROLLERS. 4-page catalog describes new line of meter-relay-type indicating controllers; gives details of characteristics, operation, damping, installation, etc. —Sensitive Research Instrument Corp., 310 Main St., New Rochelle, N. Y.

Circle **506** on inquiry card.

COMPUTING, DATA HANDLING

DATA LOGGER. 6-page catalog 30A1200 describes Series 1200 featuring "building-block" construction and flexible pinboard programming. —Fischer & Porter, 464 Jacksonville Rd., Hatboro, Penna.

Circle **507** on inquiry card.

DATA PROCESSING. 4-page Technical Bulletin 103 describes Operational Information Systems featuring solid-state digital computer with magnetic-core memory, designed specifically for industry and on-stream computation.—Daystrom Systems, Div. of Daystrom, Inc., 5640 La Jolla Blvd., La Jolla, Calif.

Circle **508** on inquiry card.

ELECTRONIC INSTRUMENTATION. 30-page catalog describes maker's line of transducers, telemetering oscillators, digital strain gage indicators, servo converters and automatic data logging instruments.—Datran Electronics, Div., Mid-Continent Mfg., Inc., 1836 Rosecrans Ave., Manhattan Beach, Calif.

Circle **509** on inquiry card.

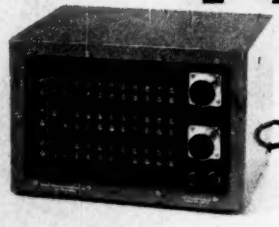
COMPUTER LANGUAGE TRANSLATOR, for all commonly-used data processing systems is described in 4-page bulletin ZA-100.—Electronic Engineering Co., 1601 E. Chestnut St., Santa Ana, Calif.

Circle **510** on inquiry card.

MAGNETIC FILE DRUMS. 4-page Bulletin HD-1 and 4-page Bulletin HD-1T describe new high-density storage units for data processing systems.—Laboratory For Electronics, Inc., Computer Products Div., 141 Malden St., Boston 18, Mass.

Circle **511** on inquiry card.

PACE



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NEW BRJ SERIES UTILIZES MAGNETIC AMPLIFIER CONTROL FOR EXTREME PRECISION —

1/5°F STABILITY

FEATURES

Long term stability within 1/5°F.

Reference temperatures from 25°F above ambient to 250°F – *Special models for reference temperatures below ambient.* Up to 48 channels in standard 110 volt rack or cabinet models. Multi-wire junctions for thermocouple choice in each channel.

150°F Reference Thermocouple Tables

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- Spindle speeds up to 26,000 rpm to engrave or for machining modern materials
- Fastest possible copy set-up
- Greatest ease and speed of adjustments
- Cutter grinders, rotary tables, master letters, compound slides, name plate blanks and all required accessories

MODEL D2 HEAVY-DUTY 2-DIMENSIONAL

- 5/5 pounds-rigid, sturdy, precise
- Vertical adjustment of copy table automatic with Pantograph
- Unobstructed on three sides to take large work
- Vertical range over 10 inches
- Micrometer adjustment for depth of cut
- Ball bearing construction throughout — super precision ball bearings in spindle
- Ratios 2 to 1 to infinity — master copy area 26" x 10"

MODEL 106 PORTABLE BENCH MODEL- 2- OR 3-DIMENSIONAL

- 40 pounds of unbeatable speed and accuracy at a reasonable price
- Perfect for all machining applications within its range
- Ball bearing spindle has three speeds up to 14,000 rpm
- 5 positive, accurate pantograph ratios
- One copy carrier (supplied) accepts all master sizes
- Height of pantograph and position of cutter are continuously adjustable
- Work up to 10" by any width
- Taper shank cutters

GREEN INSTRUMENT CO., INC.

383 Putnam Avenue Cambridge, Mass.

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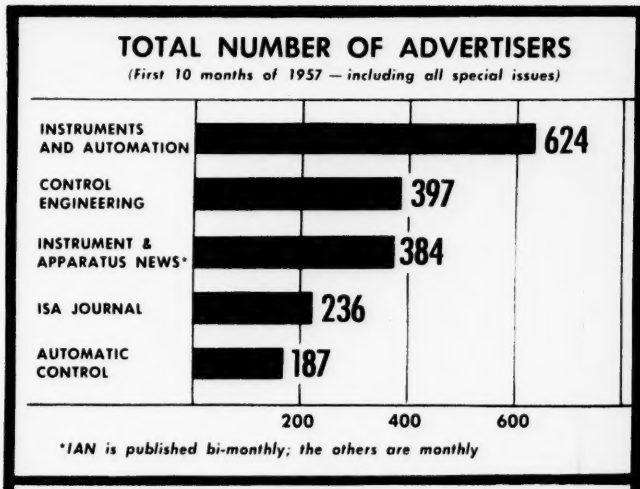
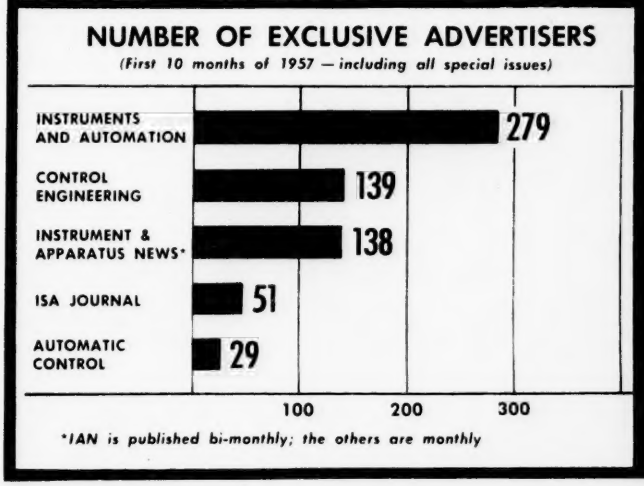




30 Years a Leader!

INSTRUMENTS and AUTOMATION closes its 30th year of service to the instrument-control field in the top position it has deservedly enjoyed throughout the past three decades...

Holding leadership is just as important as attaining it! And this most recent demonstration of advertiser preference for the Instruments Publishing Company's publications is a dramatic compliment to true leadership. The graphs reveal this entire story at a glance.

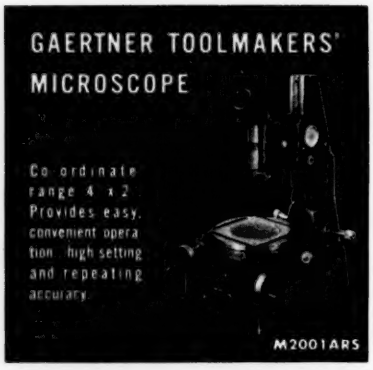
During the first 10 months of 1957, INSTRUMENTS & AUTOMATION had MORE advertisers in the industrial instrument-automatic control field than ANY OTHER magazine in the field! In the *exclusive* advertisers category, INSTRUMENTS & AUTOMATION had 100% MORE exclusive advertisers than the nearest competitor! And her bi-monthly sister publication, INSTRUMENT & APPARATUS NEWS just about equalled the other nearest competitor!

This record of leadership is just *part* of the confidence created among advertisers who have come to realize the inherent advertising and sales value of the Instruments Publishing Company publications. Why not put these publications to work for you in 1958?

INSTRUMENTS PUBLISHING CO., INC.

845 Ridge Avenue, Pittsburgh 12, Pennsylvania

INSTRUMENTS & AUTOMATION • INSTRUMENT & APPARATUS NEWS • MILITARY AUTOMATION • MEDICAL ELECTRONICS NEWS • I & A BUYERS' GUIDE


GAERTNER TOOLMAKERS'
MICROSCOPE
Co-ordinate range 4 x 2. Provides easy, convenient operation high setting and repeating accuracy.
M2001ARS

MINIMIZE REJECTS!

Precise measurement to 0.0001" and 1 min. of arc

A reliable, easy-to-use microscope for precise measurement of piece parts, tools, dies, thread gages, templates, jigs, fixtures, etc. You make direct, non-destructive measurements — no contact, no distortion, images are sharp and clear.

Used by U. S. Govt. Gage Laboratories, and by prime contractors and their subcontractors. Use of the same measuring instrument by all parties co-ordinates inspection procedures, and minimizes disagreements and rejects.

Write for Bulletin 147-56

The Gaertner Scientific Corporation

1211 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

For more information circle **165** on inquiry card.

NEW LITERATURE

AIRBORNE DATA RECORDING systems are described in a binder of 15 bulletins on wide range of transducers, carrier systems, miniature tape recorders, etc.—Northam Electronics, Inc., 2420 N. Lake Ave., Altadena, Calif.

Circle **512** on inquiry card.

DATA PROCESSING. Folder contains eight bulletins on numerical data printers, time data printer, printing timer, print-punch equipment, etc. —8-page Engineering Bulletin S-101 describes standard off-the-shelf paralleled-entry printers.—6-page Brochure SA-81 describes maker's tape punch, print-punch, scanning printer, printer-perforator combinations, time data printer, printing timer, printing input keyboard and standard data printer machines.—Clary Corp., 408 Junipero St., San Gabriel, Calif.

Circle **513** on inquiry card.

RECORDERS

MULTI-PEN ROUND-CHART RECORDER for temperatures, pressures, levels, flow-rates, voltages or currents, is described in 4-page Bulletin MSP-149.—Hagen Chemicals & Controls Inc., Hagan Bldg., Pittsburgh 30, Pa.

Circle **514** on inquiry card.

OPERATIONS RECORDER. 4-page Catalog 30A1400 describes Millisecond Operations Recorder (MOR) for continuous automatic logging of power station operations at cost ⅓ less than previous methods.—Fischer & Porter Co., 488 Jacksonville Rd., Hatboro, Penna.

Circle **515** on inquiry card.

TEMPERATURE

THERMOSTAT. Catalog sheet announces Temp-Stat which is sensitive to 0.005 C deg through range of —30 to 260 deg C.—Bayley Instrument Co., Box 538, Danville, Calif.

Circle **516** on inquiry card.

THERMAL WELLS. 2-page Catalog MC-158 describes copper and stainless steel designs for immersion and surface mounting.—Fenwal Inc., Ashland, Mass.

Circle **517** on inquiry card.

THERMAL ELEMENTS. 4-page Bulletin 110 is selection guide for bulb materials in more than 400 Atmospheres.—The Partlow Corp., 505 Campion Rd., New Hartford, N. Y.

Circle **518** on inquiry card.

PORTABLE POTENTIOMETER, six-page Bulletin T-57 describes new Thermotest I which is the only such instrument with interchangeable direct-reading scales and automatic compensation.—Technique Assocs., Inc., P. O. Box 91, Indianapolis 6, Ind.

Circle **519** on inquiry card.

New, Low Cost . . . All-Purpose

PRECISION DEVELOPMENT KIT

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A newly developed, completely integrated, kit and stock room of precision instrument parts and components—for use in all mechanical breadboard, prototypes and servo control system applications. AVAILABLE IN 1/8", 3/16" & 1/4" SHAFT SIZES.

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Special - - -

while they last - - -

THE AUTOMATIC FACTORY

by Stephen A. June, J. D. Bardis, L. H. Lurio, L. S. Polaner, O. Sagedahl, H. A. Sklenar and B. K. Yenken.

$1.50 Postpaid

Here is a fresh viewpoint on what tomorrow's "manless factories" CAN be—a book entirely free from the boresome generalities, platitudes, exaggerations and misconceptions that have been repeated by the majority of writers on this subject.

The viewpoint is fresh because the authors sought the TRUTH in the course of their project under General George F. Doriot at the Harvard School of Business Administration.

Here, then is THE book for all those who want FACTS rather than wild opinions.

88 pages, illustrated, 1955.

INSTRUMENTS PUBLISHING CO.
845 Ridge Ave., Pittsburgh 12, Pa.

FURNACES, CONTROLLERS. 20-page Catalog No. 57 describes TEMCO line of laboratory and industrial electric furnaces, hot plates, temperature controllers, pyrometers, flask heaters, and magnetic stirring hot plates.—Thermo Electric Mfg. Co., 511 Huff St., Dubuque, Iowa.

Circle **520** on inquiry card.

THERMOSTAT METALS. 4-page Technical Bulletin TRU-6 summarizes test results of corrosion-resistant thermostat metals in humid atmospheres, hot water, salt spray, etc.; includes a relative cost chart, a comparative thermal deflection graph, and a listing of mechanical and physical properties.—General Plate Div., Metals & Controls Corp., Attleboro, Mass.

Circle **521** on inquiry card.

FLOW, LEVEL, PUMPS

FLOW INSTRUMENTATION. 4-page condensed Bulletin M-1 covers instruments for indicating, recording, and controlling flow-rate of all fluids.—Schutte and Koerting Co., Instrument Div., Cornwells Heights, Bucks County, Penna.

Circle **522** on inquiry card.

MAGNETIC FLOWMETER. 4-page Catalog 10D1416 discusses principle and operation of magnetic flowmeters, describes maker's unit.—Fischer & Porter Co., 461 Jacksonville Rd., Hatboro, Penna.

Circle **523** on inquiry card.

LEVEL CONTROL. 8-page Bulletin J57 describes new Dynatrol Type C1-10 which employs a unique vibrating-paddle method, sensitive to a 0.01" change in level of liquids, slurries, or granular materials.—Automation Products, Inc., 3030 Max Roy St., Houston 24, Texas.

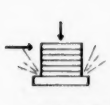
Circle **524** on inquiry card.

SEALED GEAR PUMP. 2-page Technical Reference 57D describes sealed gear pump for mounting on any machine which requires fluid circulation for lubrication or other purposes.—Bijur Lubricating Corp., Rochelle Park, N. J.

Circle **525** on inquiry card.

SLURRY FEEDER. 4-page Publication TP-10-M describes Series A-710 self-contained unit for extremely accurate and reliable feeding of concentrated slurries.—Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J.

Circle **526** on inquiry card.



WEIGHT, LOAD PRESSURE

SUPERPRESSURE INSTRUMENTATION. 125-page Catalog No. 407 superseding No. 406 lists hundreds of standard and accessory high pressure items, as well as custom-built superpressure equipment, designed for use at pressures up to 100,000 psi and temperatures to 1000°F.—American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.

Circle **527** on inquiry card.

Tiffen LAMINATED & SOLID GLASS FILTERS
INDUSTRIAL • SCIENTIFIC • PHOTOGRAPHIC

Tiffen PRECISION OPTICS
WINDOWS • PRISMS • WEDGES

Tiffen SPECIALIZED GLASS
VYCOR • PYREX • QUARTZ

Tiffen PRECISION HOLE DRILLING
TOLERANCES TO .0001"

Tiffen PRECISION EDGING SAWING, MACHINING
ON ALL TYPES OF GLASS & CERAMICS

Tiffen PRECISION OPTICAL MACHINING
METAL LENS MOUNTS • BARRELS • EYEPIECES

AUTOMATIC SCREW MACHINES to 4" dia.—Also Hand Screw Machines—English & Metric Threads our specialty.

Write for Filter Transmission Curve Catalog.

Tiffen QUALITY PRODUCTS
TIFFEN MARKETING CO.
INDUSTRIAL DIVISION
71 Jane St., Roslyn Heights, L.I., N.Y.

For more information circle **167** on inquiry card.

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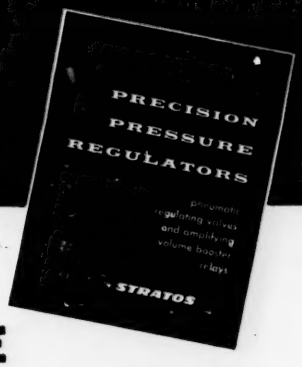

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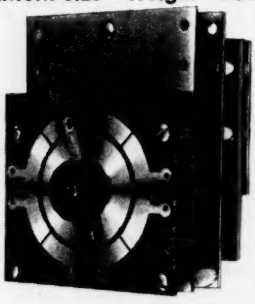

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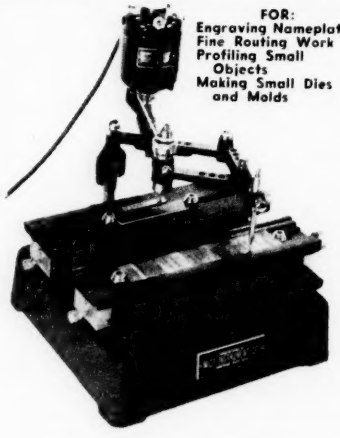

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NEW LITERATURE

DIFFERENTIAL PRESSURE TRANSMITTER. 4-page Catalog 10B1465 describes new force-balance unit featuring measuring circuit parts sealed off in silicone oil and adjustable damping within measuring circuit.—Fischer & Porter Co., 490 Jacksonville Rd., Hatboro, Penna.

Circle **528** on inquiry card.

MINIATURE PRESSURE SWITCHES. Two-page bulletin describes bulkhead-mounting Models 65M90, 65M91 and 65M92 of Pressure Capswitches that can be grouped on 1.09" centers.—Robertshaw-Fulton Controls Co., Bridgeport Thermostat Div., Milford, Conn.

Circle **529** on inquiry card.

PRESSURE SWITCH. Two-page bulletin describes AeroSwitch for extremely severe temperature, vibration and explosive pressure surge conditions (originally developed for rockets).—Aerojet General Corp., Subs. of General Tire & Rubber Co., Sacramento, Calif.

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VAPOR-PRESSURE RECORDER. 4-page bulletin describes Models 1157 and 1158 (Shell Development Co. design) for gasolines or liquefied petroleum gases.—Hallikaninen Instruments, 1341 Seventh St., Berkeley 10, Calif.

Circle **531** on inquiry card.

TANK WEIGHING. 4-page Bulletin 571 describes the new concept of tank weighing as a measurement of tank contents.—The A. H. Emery Co., New Canaan, Conn.

Circle **532** on inquiry card.

AUTOMATIC PROPORTIONING CONTROL. 12-page reprint entitled "Automation in the Mill," describes latest digital printout techniques for automatic proportioning control.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.

Circle **533** on inquiry card.

LOAD SWITCHES. 2-page Bulletin 49E describes complete line of Force Control Switches, furnished with one to four adjustable switches, in tension or compression.—W. C. Dillon & Co., Inc. 14620 Keswick St., Van Nuys, Calif.

Circle **534** on inquiry card.

HUMIDITY, WATER, AIR

HUMIDITY AND TEMPERATURE INSTRUMENTATION. 6-page catalog describes indicators, recorders and controllers, including rugged indoor-outdoor models.—Serdex, Inc., 12 Bowdoin Square, Boston 14, Mass.

Circle **535** on inquiry card.

WATER VAPOR INDICATOR. 8-page Bulletin 2301 describes instrument for measuring water-vapor content of compressed gases, includes schematics, flow diagrams, and table of properties of partly saturated air-water vapor mixtures.—American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.

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AIR CONDITIONING for electronic systems is discussed in 4-page bulletin which describes complete line of Mil-Ac custom units automatically controlled to ventilate, circulate, cool, heat, filter, humidify and dehumidify. —Ellis & Watts Products, Inc., P. O. Box 33, Cincinnati 36, Ohio.

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VALVES

ANTI-CORROSION VALVE. Catalog page announces new control valve that safeguards products and itself with Teflon body, stuffing-box, stem, seat, plug and other components.—George W. Dahl Co., Inc., 86 Tupelo St., Bristol, R. I.

Circle **538** on inquiry card.

POSITION INDICATOR. 2-page bulletin describes Capswieth Position Indicator which attaches to a valve, actuator, etc., and signals when opening or closing cycle has been completed.—Robertshaw-Fulton Controls Co., Bridgeport Thermostat Div., Milford, Conn.

Circle **539** on inquiry card.

TEMPERATURE CONTROL VALVES. 6-Page Bulletin 655, "How to Select, Size, and Order Temperature Control Valves," tells how to select proper body material, valve trim, thermal systems, etc.—Jordan Industrial Sales Div., OPW Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle **540** on inquiry card.

TEMPERATURE REGULATORS. Four page Catalog Section VII describes No. 650 and No. 651 self-operating vapor-pressure-operated temperature regulators, both with 60° F to 240° F ranges.—Atlas Valve Co., 280 South St., Newark 5, N. J.

Circle **541** on inquiry card.

LABORATORY, ANALYTICAL

OXYGEN ANALYSIS for steam plants, 4-page Application Data Sheet 463-60 describes new L&N Magnetic 0_2 System for Flue Gas Analysis.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **542** on inquiry card.

INTERFERENCE REFRACTOMETER. 4-page Bulletin 2290 describes the new type Aminco-Jonnard Refractometer, which measures refractive index differences to an accuracy of 0.00002 and permits measuring dispersion of solutes, concentration of extremely dilute solutions and determination of refractive index differences for molecular weight by light scattering.—American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.

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FLOW COLORIMETERS. Four-page Bulletin 4000 describes standard Model 77 and new Ratio Recorder, which continuously measure color intensity, turbidity, or chemical concentration. —Beckman/Process Instruments Div., Fullerton, Calif.

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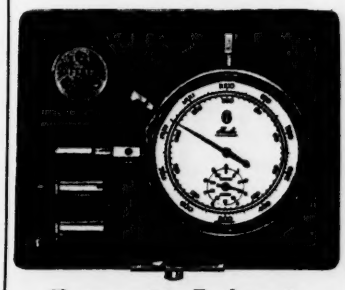

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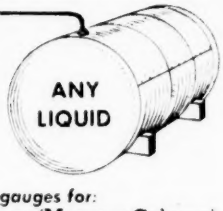

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NEW LITERATURE

VISCOSIMETER. 2-page Bulletin V-1218 describes maker's Viscometer for polymerization and other similar processes.—Norcross Corp., 247 Newtonville Ave., Newton 58, Mass.

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H-F INDUCTION UNITS. 16-page Bulletin T-1067 is a catalog of maker's high-frequency induction units and accessories for rapid high temperature combustion of laboratory samples.—Laboratory Equipment Div., Lindberg Engineering Co., 2444 W. Hubbard St., Chicago 12, Ill.

Circle **546** on inquiry card.

POLYETHYLENE LAB WARE is fully covered in 16-page Catalog 57P which describes about 100 items.—Schaar & Co., 7300 W. Montrose Ave., Chicago 34, Ill.

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OPTICAL

REMOTE VIEWING. 4-page Bulletin 301 covers design and use of Industrial Periscopes.—Kollmorgan Optical Corp., 347 King St., Northampton, Mass.

Circle **548** on inquiry card.

PHOTOMICROGRAPHY. 12-page brochure describes Orthopot universal photomicrographic cameras and accessories.—American Optical Co., Instrument Div., Buffalo 15, N. Y.

Circle **549** on inquiry card.

TESTING, GAGING

CREEP TESTS. 2-page Process Data Sheet 247(1) describes maker's temperature control equipment for stress-rupture and creep testing; lists and illustrates auxiliary equipment.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **550** on inquiry card.

ENGINE TESTING SYSTEM. 4-page Application Bulletin 58-112 describes S-100 automatic data handling and recording system for engine test facilities.—BJ Electronics, Borg-Warner Corp., 3300 Newport Blvd., Santa Ana, Calif.

Circle **551** on inquiry card.

ELECTRICAL GAGING. 4-page Bulletin A-580 describes new Electro-Probe Electronic Test Indicator, and Sure-Set electronic table positioning device for universal grinders.—Federal Products Corp., 1144 Eddy St., Providence 1, R. I.

Circle **552** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

REPEATER 'SCOPE. 2-page catalog insert announces 21" SlaveScope for production-line testing, computer readouts, lectures, etc.—Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

Circle **553** on inquiry card.

LINE AND CABLE FAULT LOCATOR. Two-page Data Sheet E-53(11) describes Type U Test Set designed for use by linemen.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **554** on inquiry card.

BRIDGE BALANCE-SYSTEM. 2-page Bulletin BBU-A describes Model 6-104 unitized subminiature system for automatically calibrating up to 24 transducer channels, in ground or airborne applications.—B & F Instruments, Inc., 4732 N. Broad St., Phila. 41, Pa.

Circle **555** on inquiry card.

TRUE RMS VOLTMETER. Two-page Bulletin No 27 describes Model TBM featuring panel-switch selection: fast for quick reference, slow for exact measurement. Bulletin No. 28 describes Model SND which accepts two independent input signals and permits user to select as output either their sum or difference, or either alone.—Flow Corp., 85 Mystic St., Arlington 74, Mass.

Circle **556** on inquiry card.

FREQUENCY METERS. Binder contains 8 sheets describing new line of frequency meters, with tables of characteristics.—Varo Mfg. Co., Inc., 2201 Walnut St., Garland, Texas.

Circle **557** on inquiry card.

ELECTRONIC INSTRUMENTS. Short-form pocket catalog describes Model CL 100 Accelerator Current Integrator, Model PH-200 Universal Photomultiplier Photometer, Model TH-300 Milli-Micro-second Time-to-Pulse Height Convertor, and Model PA-400 Multi-channel Pulse-Height Analyzer.—Eldorado Electronics Co., 2821 Tenth St., Berkeley, Calif.

Circle **558** on inquiry card.

TIME DELAY GENERATORS. 2-page bulletin describes Series 1000 instruments for generating variable-width millisecond-range pulses with calibrated delay to 10 seconds from integral or external triggers.—Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Circle **559** on inquiry card.

GROUND DETECTOR. 4-page bulletin describes PRD-C5700 Three-phase ground detector and alarm control which also detects unbalanced loads, arcing and surging, etc.—Principle Research & Development Corp., Box 93, Franklin Park, Ill.

Circle **560** on inquiry card.

CONTACT-TYPE CONTROLLERS. 16-page Catalog AC-2 covers extensive line of meter-relay type indicating controllers; includes application data, accessory equipment, etc.—Tipptronic, Inc., Chagrin Falls, Ohio.

Circle **561** on inquiry card.

POWER SUPPLIES

B-POWER SUPPLY. Two-page Special Bulletin describes new Model 300-B printed-circuit wide-range B-Nobatron with a regulated output of 0-300 vdc and unregulated filament voltage outputs of 6.3 or 12.6 vac.—Sorenson & Co., Inc., Richards Ave., S. Norwalk, Conn.

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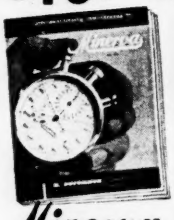

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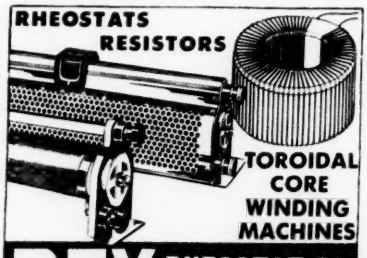

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NEW LITERATURE

VARIABLE TRANSFORMER. Brand-Interchangeability chart, 4-page cross-reference chart provides equivalent data on type number and output amperage of Adjust-A-Volt, Powerstat and Variac variable transformers.—Standard Electrical Products Co., Dept. A15, 2240 E. Third St., Dayton, Ohio.

Circle **563** on inquiry card.

SILICON SOLAR BATTERIES. 2-page Bulletin SR-156 describes new series of high-efficiency silicon photovoltaic cells with spectral-response peak in near-infrared.—International Rectifier Corp., El Segundo, Calif.

Circle **564** on inquiry card.

SELENIUM RECTIFIERS. Bulletin 248A describes new high-current-density PettiSel industrial type selenium rectifiers, gives data on uprating rectifiers when cooled by forced air.—Radio Receptor Co., Inc., 240 Wythe Ave., Brooklyn 11, N. Y.

Circle **565** on inquiry card.

RESISTORS,

VOLTAGE-DIVIDING RESISTOR. 4-page Data Sheet 54-15 describes Series 9300 three-turn Precision Potentiometer.—Beckman/Helipot Corp., Newport Beach, Calif.

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RESISTANCE FILAMENTS with high positive coefficients, available in perfectly matched pairs for gas analysis, anemometers and vacuum gages, are described in 2-page Bulletin Fil 12-57.—Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J.

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CARBON-FILM RESISTORS. 4-page Engineering Bulletin 7010 describes ceramic-cased Types 402E, 403E and 404E Filmistors for close-tolerance military and industrial applications.—Sprague Electric Co., Marshall St., North Adams, Mass.

Circle **568** on inquiry card.

RELAYS, SWITCHES

POWER RELAY. Four-page engineering data folder describes Type 33B general-purpose unit especially suitable for process controls, welding timers, etc.—Phillips Control Corp., 59 W. Washington St., Joliet, Ill.

Circle **569** on inquiry card.

INERTIA SWITCH. 2-page bulletin describes 3¾-oz device which momentarily closes electrical contacts when subjected to a horizontal impact exceeding preset valve.—Safe Lighting Inc., 527 Lexington Ave., New York, N. Y.

Circle **570** on inquiry card.

WIRE-MARKING MACHINE. Product Data Sheet 195-A describes Markermatic for use with Perma-Code wire markers and Blue Streak dispenser cards.—W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis.

Circle **571** on inquiry card.

ELECTRICAL, ELECTRONIC COMPONENTS

CONNECTORS. 44-page Plug Guide covers 53,000 connectors, gives checklist including size, number and style of contacts, mounting space, coupling methods, insulation and environmental conditions—Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Circle **572** on inquiry card.

RF SWITCHING. 4-page Number 3 of "Increductor Notes" is a 3-page technical article, with fourth page describing Series AB high-Q fast-sweep Mc-range models.—CGS Labs., Inc., 391 Ludlow St., Stamford, Conn.

Circle **573** on inquiry card.

TRANSISTOR INTERCHANGEABILITY guide, 4-page bulletin has two pages of specifications and a full-page tabular guide.—Industro Transistor Corp., 649 Broadway, New York 12, N. Y.

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METALLIC RECTIFIERS. 4-page RN-1057 contains articles on silicone diode Zener voltage measurement; on new solar cells; etc.—International Rectifier Corp., El Segundo, Calif.

Circle **575** on inquiry card.

ELECTRIC CLUTCHES, BRAKES. 4-page Bulletin CB 160 describes clutch coupling, electric clutch, combination clutch & brake, electric brake, and duplex clutch.—Simplatrol Products Corp., 24 Salisbury St., Worcester, Mass.

Circle **576** on inquiry card.

ELECTRICAL COILS. 4-page bulletin gives illustrated examples of varied uses.—Electrocoils, Inc., 1301 New Willow St., Trenton 8, N. J.

Circle **577** on inquiry card.

CAPACITORS. 6-page Engineering Bulletin 3520B describes sealed subminiature Tantalex Type 150D solid-electrolyte type in great detail, with graphs, tables, etc.—8-page Engineering Bulletin 2610 describes Types 141P and 142P Filmite G in sealed metal cases for high-temperature applications.—8-page Engineering Bulletin 2560 describes Types 139P and 140P Filmite F featuring capacitance stability in variable temperature environments.—Sprague Electric Co., North Adams, Mass.

Circle **578** on inquiry card.

SCOPE CARRIERS. 2-page bulletin describes OS-Cart trays, dollies and rolling tables for oscilloscopes.—Technibilt Corp., 905 Air Way, Glendale 1, Calif.

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MECHANICAL COMPONENTS

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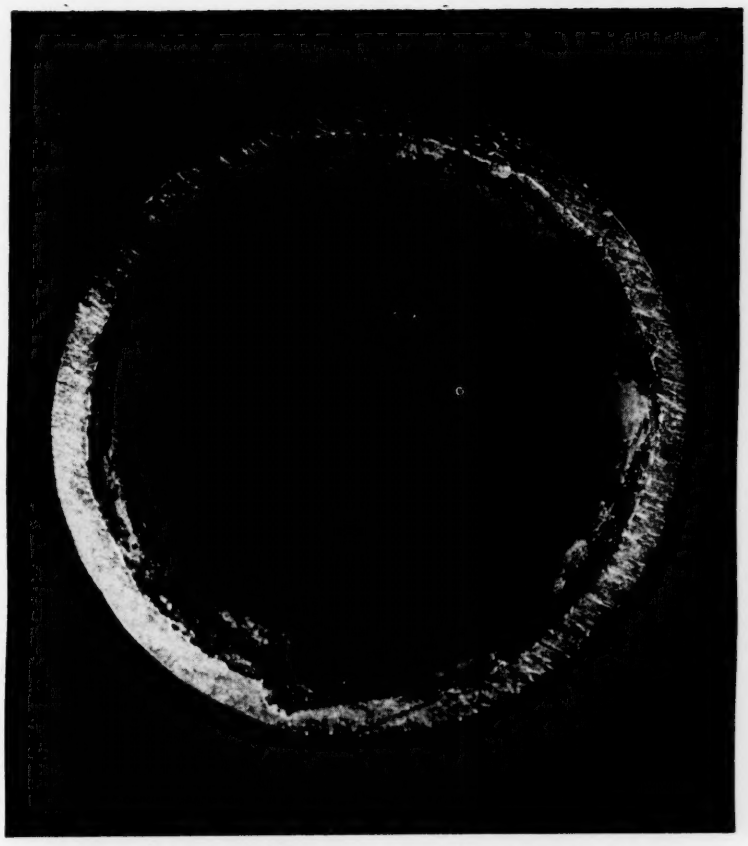

Using vertical polarized light on a cross-section of pipe, photographer Bernard Hoffman clearly shows the ravages of corrosive action.

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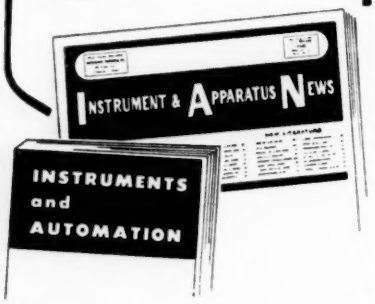

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NEW LITERATURE

tects bolt ends, and a washer base wing nut which replaces a regular wing nut and a flat washer.—Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y.

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SPRING MOTOR. Two-page Issue No. 6 of "Neg'ator Sketchbook" is an article on application of Neg'ator motor in liquid-level measuring devices.—Hunter Spring Co., Lansdale, Penna.

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SHAFT COUPLINGS. 4-page Bulletin 98 describes various applications of full-floating shaft couplings used to connect shafts that are spaced far apart.—Thomas Flexible Coupling Co., Warren, Pa.

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FABRICATION

HEAT TREATING. 12-page folder on the "Tri-arb" method describes new L & N protected-quench furnace equipments.—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.

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MACHINERY MAINTENANCE. 4-page illustrated booklet describes maker's complete line of test instruments.—International Research and Development Corp., P. O. Box #55, Worthington, Ohio.

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CONTINUOUS RESISTANCE WINDER. Catalog page describes automatic Model 209 which winds resistance wire up to 7/32" OD on continuous lengths of flat or round core material.—Geo. Stevens Mfg. Co., Pulaski Rd., at Peterson, Chicago 30, Ill.

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SELF-ADHERING IDENTIFICATIONS. 28-page binder-type catalog covers labels, wire markers, "E-Z Code," "Tel-A-Pipes," safety signs, etc.—Westline Products Div., Western Lithograph Co., 600 E. 2nd St., Los Angeles 54, Calif.

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SURPLUS EQUIPMENT. 28-page Surplus Division Catalog 43 lists new synchros, ad/dc motors, servomotors, inverters, actuators, generators, etc.—Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J.

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MISCELLANEOUS

MARINE COMBUSTION CONTROL SYSTEM. 8-page Bulletin MSA—144 describes the five components: master sender, damper operator, boiler relay, air-fuel ratio regulator, and oil control valve.—Hagen Chemical & Controls, Inc., Hagen Building, Pittsburgh 30, Pa.

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POSITIONING CONTROLS. New 8-page Bulletin J-101 describes maker's electrical remote positioning controls including shaft-mounted gearmotor and variable speed drives for speed, proportion and tension.—Jordan Co., Inc., 3235 W. Hampton Ave., Milwaukee 9, Wis.

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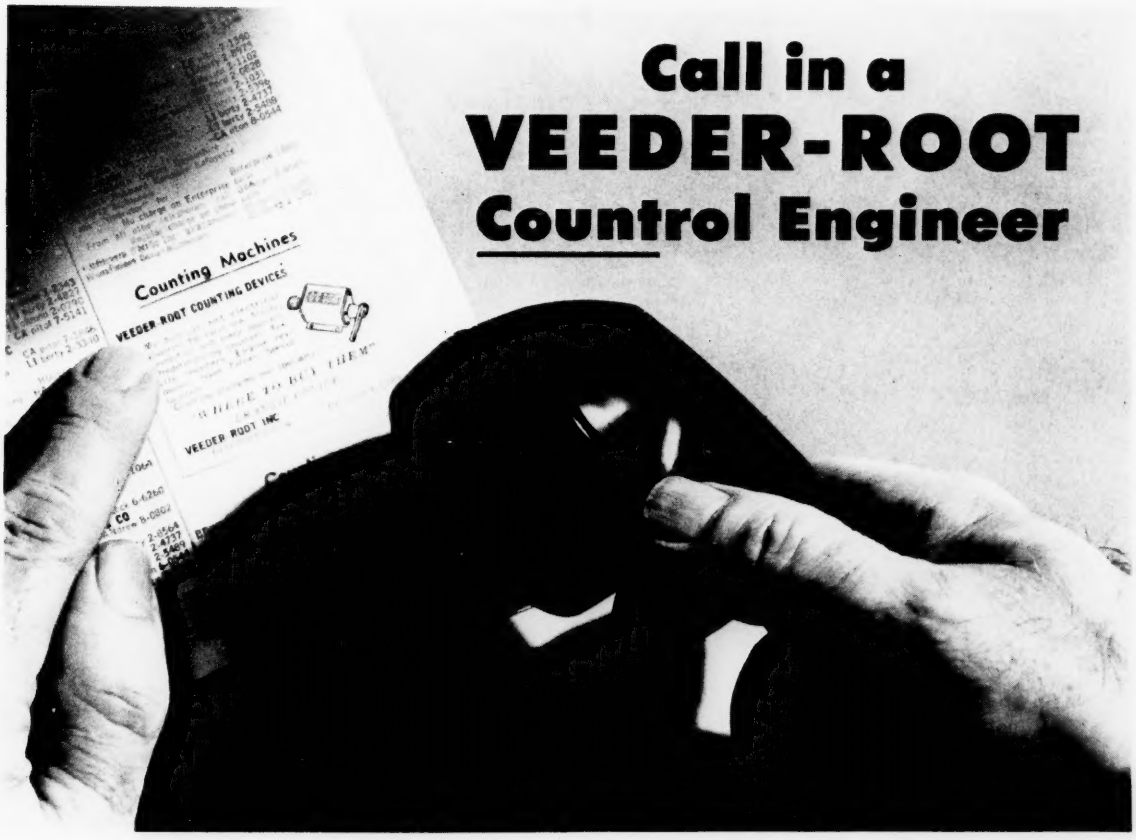

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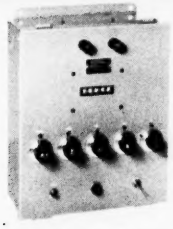

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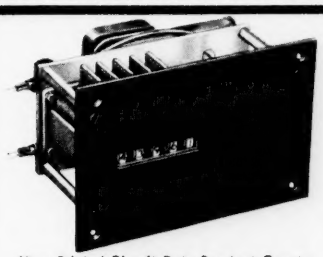

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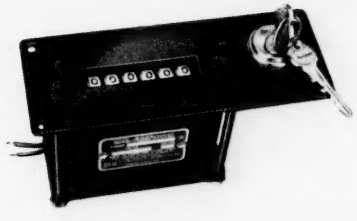

New Panel-Mount Magnetic Counter with Lock-Key Reset

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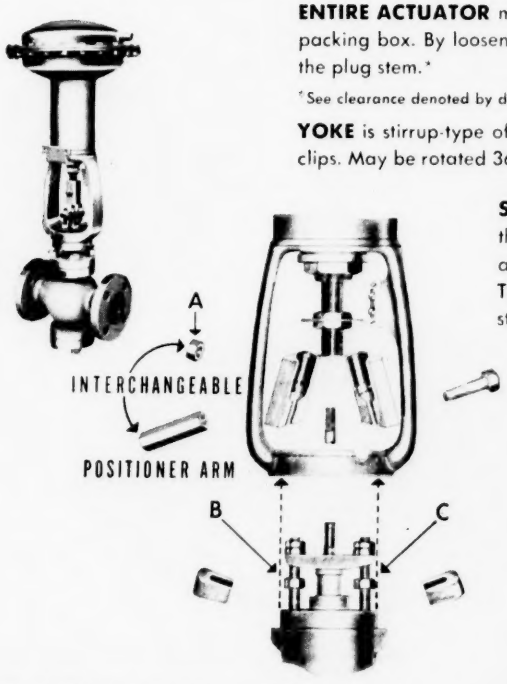

ENTIRE ACTUATOR may be removed and replaced without disturbing the packing box. By loosening nuts A, B, and C the actuator may be lifted over the plug stem.*

*See clearance denoted by dotted lines and arrows.

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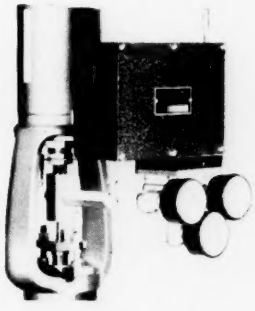

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